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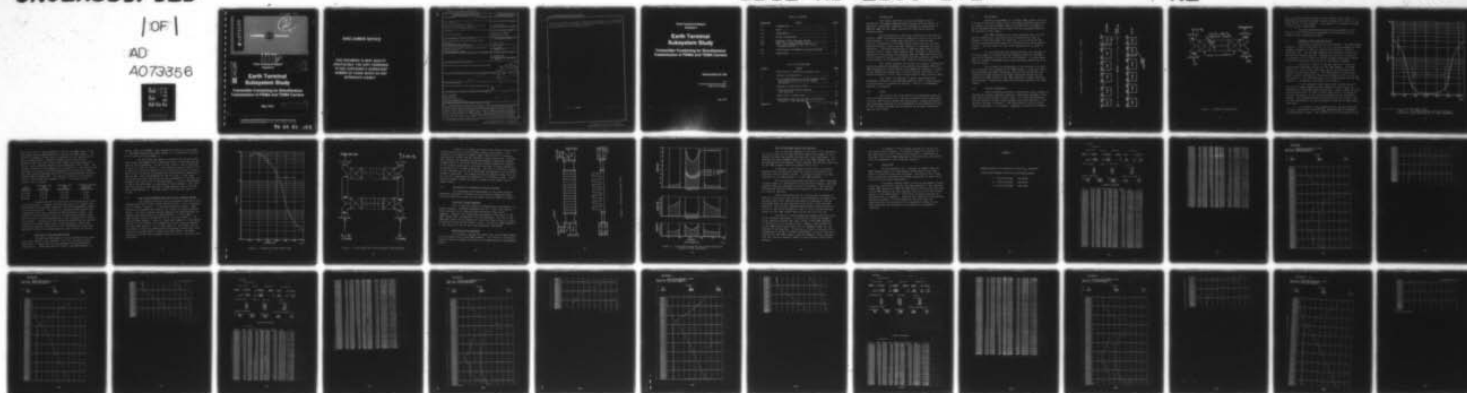
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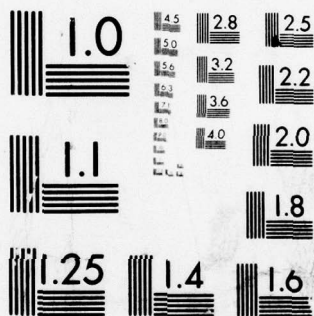


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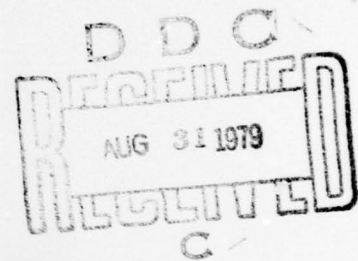
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Final Technical Report  
Volume 4



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# Earth Terminal Subsystem Study

## Transmitter Combining for Simultaneous Transmission of FDMA and TDMA Carriers

May 1979

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in terms of insertion loss, phase linearity, and complexity. It is concluded that the bandpass filter approach is the preferred approach, based on its low-loss characteristics and its design simplicity.

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**Final Technical Report  
Volume 4**

# **Earth Terminal Subsystem Study**

**Transmitter Combining for Simultaneous  
Transmission of FDMA and TDMA Carriers**

***Subcontract S-165***

For  
Computer Sciences Corporation  
Falls Church, Virginia

**May 1979**

## TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
1.0	INTRODUCTION .....	1
2.0	SCOPE .....	1
3.0	REQUIREMENTS .....	2
4.0	DESIGN ALTERNATIVES .....	2
4.1	Bandpass Filter Diplexer Design .....	5
4.2	Band Stop Filter Diplexer Design .....	7
4.3	Dual E-Stub Wideband Band Stop Filter Diplexer Design .....	8
5.0	EVALUATION OF ALTERNATIVE DIPLEXER DESIGNS ....	11
6.0	CONCLUSIONS .....	15

## LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	DSCS Phase III Satellite Frequency Plan .....	3
2	Diplexer Configuration .....	4
3	Loss Characteristics of 5-Pole Bandpass Filter when Constructed with WR 137 Copper Waveguide .....	6
4	Response of Band Stop Filter .....	9
5	E-Stub Band Stop Filter Diplexer Configuration .....	10
6	Seven Cavity E-Stub Filter .....	12
7	Calculated Losses for the Three Alternative Diplexer Filter Approaches .....	13

## Appendix A

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## 1.0

### INTRODUCTION

This report describes the work performed by Harris Corporation, Government Communications Systems Division (GCSD), on Subtask 4, Transmitter Combining for Simultaneous Transmission of FDMA and TDMA carriers under Subcontract S-165, Earth Terminal Subsystem Study.

The introduction of TDMA into the DSCS will mean that CW carriers (FDMA) and pulsed carriers (TDMA) must co-exist in the same earth terminal. If a common power amplifier is used for both carriers, degradation of the FDMA signals would occur due to cross-modulation effects unless the power amplifier is operated far below saturation. Efficient transmission of FDMA and TDMA signals simultaneously from a single earth terminal will, therefore, require the combining of the outputs from separate FDMA and TDMA power amplifiers. No such capability exists in the AN/FSC-78 (HT) terminals and none is being provided in the AN/MS-61 (MT) terminals being procured.

This report presents the results of a study of alternative diplexing/combining approaches for achieving simultaneous FDMA and TDMA transmissions in the AN/FSC-78 and AN/MS-61 terminals. Because of the commonality between the HT and MT terminal electronics, all efforts addressed in this study are applicable to both terminal types.

This report is organized to define requirements and assumptions relative to the diplexer/combiner; this is then followed by an evaluation of alternative designs. Finally, a recommended approach is presented.

## 2.0

### SCOPE

The scope of the study effort to be performed under this task is limited primarily to a review of previous Harris experience in filter and diplexer design and construction. Design and fabrication experience obtained in the development of the diplexers for the MT and LT antenna systems will be used as the primary information base for this study.

### 3.0

#### REQUIREMENTS

The basic requirement is to diplex FDMA signals from the existing TWT HPA with signals from a new TDMA transmitter which will be located in the RF Equipment Room of the AN/FSC-78 or AN/MS-61. The RF Equipment Room of both terminals can be considered identical for purposes of this study.

The TDMA transmitter will have an output power of 5 kW and will operate at a 10% duty cycle at a 60 MHz burst rate in Channel 1 of the DSCS Phase III Satellite. The existing TWT HPA will be transmitting FDMA signals in a 40 MHz band in both Channels 2 and 6. The DSCS Phase III satellite frequency plan is shown in Figure 1.

It is assumed that the TDMA transmitter will operate at full peak power of 5 kW and that the composite power of the FDMA carriers in Channels 2 and 6 will be 2 kW maximum. It is desirable that all diplexer components have a power handling capability of at least 10 kW CW.

The criteria for performance of the diplexer is to minimize insertion loss, especially for FDMA signals. To prevent interaction between the TDMA transmitter and the existing TWT HPA, the rejection of TDMA signals at the FDMA transmitter output and the rejection of FDMA signals at the TDMA transmitter output should be 20 dB minimum. Group delay should be minimized especially for TDMA signals.

### 4.0

#### DESIGN ALTERNATIVES

Three alternative diplexer configurations were studied to perform the channel combining function; conventional bandpass filter, band stop filter and dual E-stub filter. All three configurations use two identical filters placed between short-slot hybrids of 3 dB couplers as shown in Figure 2. The functioning of such a filter/hybrid combination is as follows: frequency  $F_1$  enters port number 2

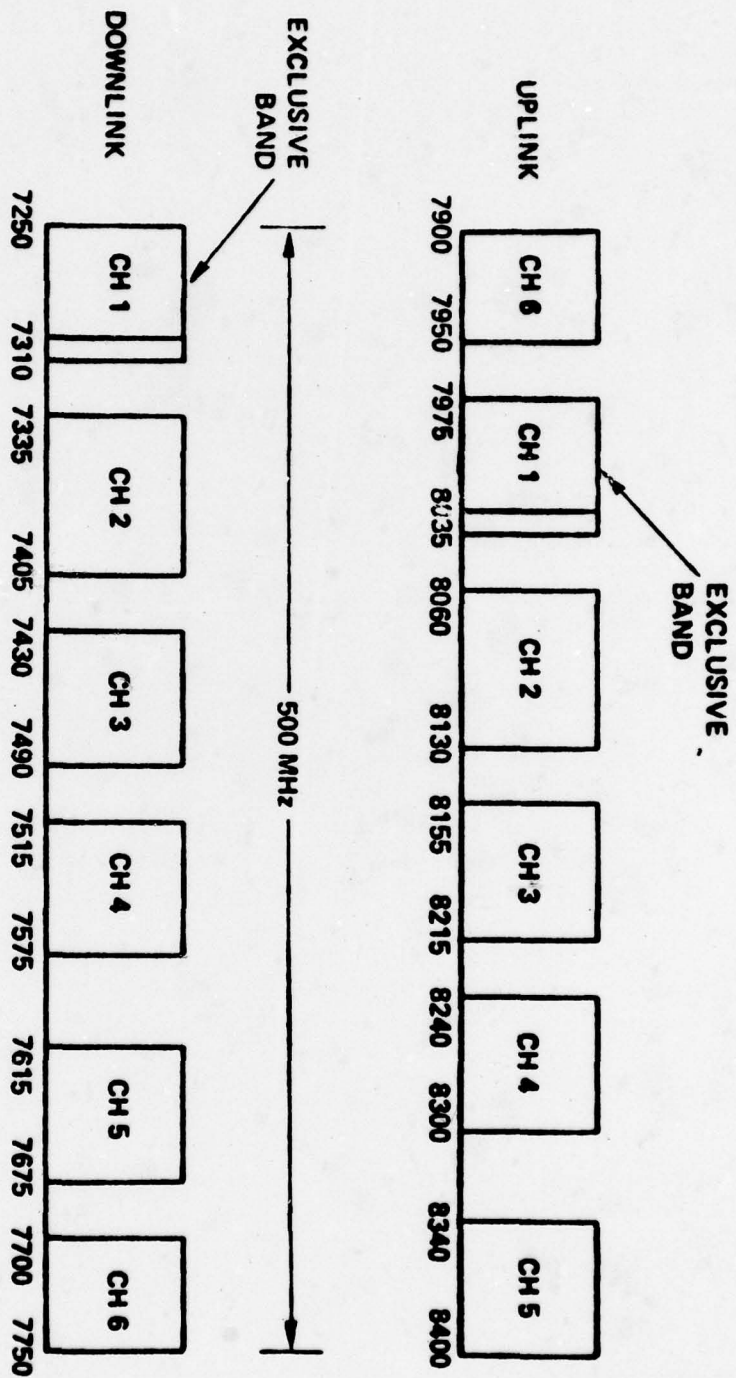


Figure 1. DSCS Phase III Satellite Frequency Plan

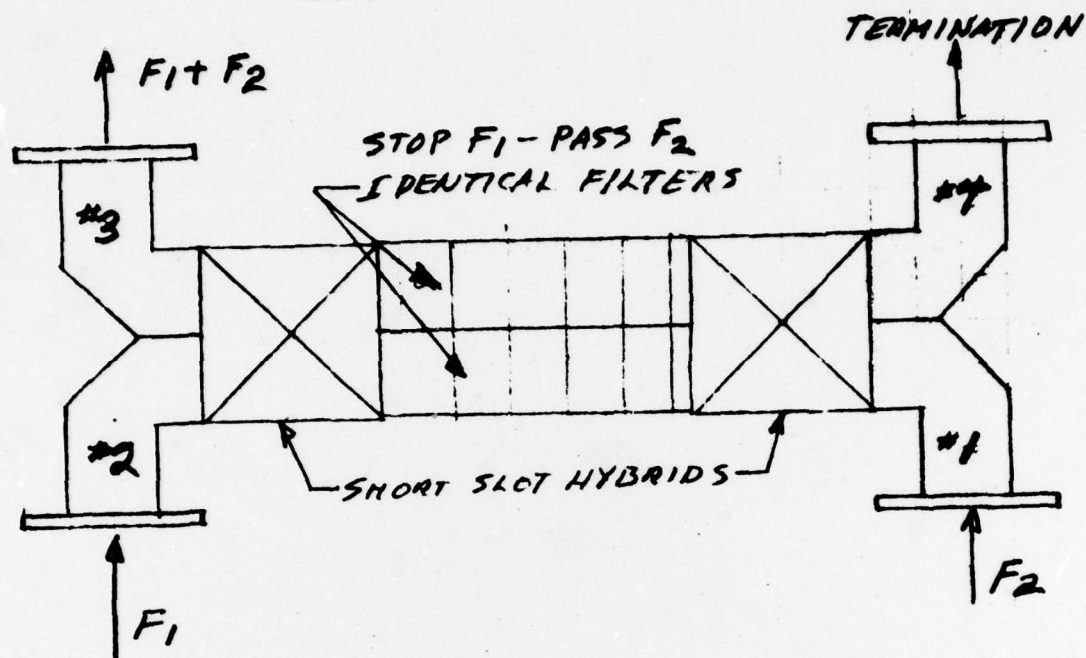


Figure 2. Diplexer Configuration

and is totally reflected by the filters and exits port number 3. Frequency  $F_2$  enters port number 1 passes through the filters and combines with  $F_1$  at port number 3. Port number 4 is isolated from both  $F_1$  and  $F_2$  and is terminated.

The three alternative diplexer configuration, all of which use the filter/hybrid arrangement described above, are discussed in the following paragraphs.

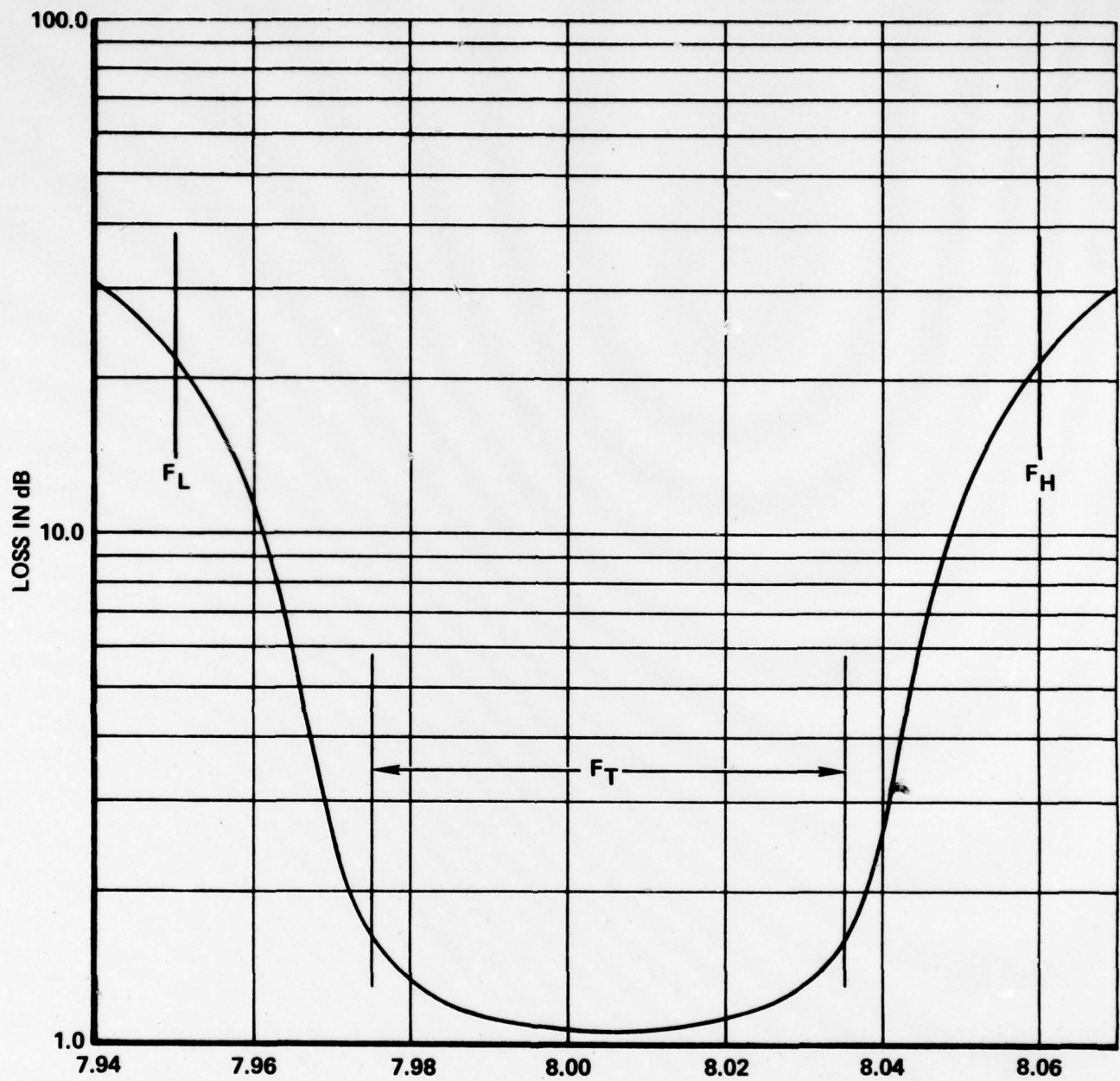
#### 4.1 Bandpass Filter Diplexer Design

Three bands (channels) must be combined. The TDMA channel, Channel 1, 7.975 to 8.035 GHz ( $F_T$ ) is to be inserted between two FDMA channels, Channel 6, 7.900 to 7.950 GHz and Channel 2, 8.060 to 8.130 GHz ( $F_H$ ). The two FDMA channels are the output from the TWT HPA and are already combined. Although not given as a constraint for purposes of this study, the uplink frequency band above Channel 2 (8.130 to 8.400 GHz) should also be considered a bandpass.

Referring to Figure 2, the two identical filters are constructed as bandpass filters for the TDMA channel. The FDMA channels,  $F_L$  and  $F_H$  enter port number 2 and are reflected by the filters and exit port number 3. The TDMA channel  $F_T$  enters port number 1 passes through the filters and combines with  $F_L$  and  $F_H$  at port number 3. The combined output of the TDMA channel and the FDMA channels, is therefore, available at port number 3.

If the bandpass filters were direct coupled and built with WR 137 copper waveguide using symmetrical vane irises, an unloaded Q of about 8000 might be obtained. Figure 3 shows the bandpass characteristics of such a filter consisting of five poles to provide a minimum of 20 dB isolation between the two transmitter outputs. The complete combiner losses would be very low (0.1 dB) for the FDMA channels but would approach 2.0 dB at the TDMA channel band edges.

A variation of this bandpass filter design consisting of high Q cylindrical cavities  $TE_{011}$  mode provides an unloaded Q of approximately 18,000. The insertion loss of the diplexer using



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Figure 3. Loss Characteristics of 5-Pole Bandpass Filter when Constructed with WR 137 Copper Waveguide

this type filter is approximately 0.7 dB for the TDMA signal at the band edges and has approximately 0.1 dB loss for FDMA signals. The design of bandpass filters such as required for this application is very straightforward. Computer programs exist to accurately determine insertion loss, return loss (VSWR), and phase characteristics. Such a computer analysis was performed for this filter. The results are shown in the computer run in Appendix A. The analysis was performed using three different bandwidths to determine the lowest loss that could be obtained while still providing adequate isolation between FDMA and TDMA bands. The design is based on a five cavity 0.04 dB ripple Chebyshev bandpass filter. The results of the analysis are as follows:

<u>TDMA Bandwidth</u>	<u>Insertion Loss TDMA Band Edges</u>	<u>Insertion Loss TDMA Band Center</u>	<u>Isolation Between TDMA and FDMA Ports</u>
62.0 MHz	0.82 dB	0.55 dB	25 dB
64.0 MHz	0.77 dB	0.50 dB	23 dB
66.0 MHz	0.70 dB	0.46 dB	21 dB

The widest filter (66 MHz) also provides the least isolation between ports. However, the isolation was still greater than the minimum 20 dB required, therefore, the 66 MHz bandwidth appeared to be the best choice. The effect of reflecting FDMA signals from a nonperfect short was a concern for QPSK modulated signals. The nonperfect short manifests itself as an amplitude and phase characteristic which can cause degradation of the orthogonality of quadrature signals. Inspection of the reflection coefficient and angle of reflection has shown these values to be negligible. Hence, the 66 MHz wide bandpass filter used in this configuration should have negligible effect on the FDMA channels except for the 0.1 dB loss.

#### 4.2 Band Stop Filter Diplexer Design

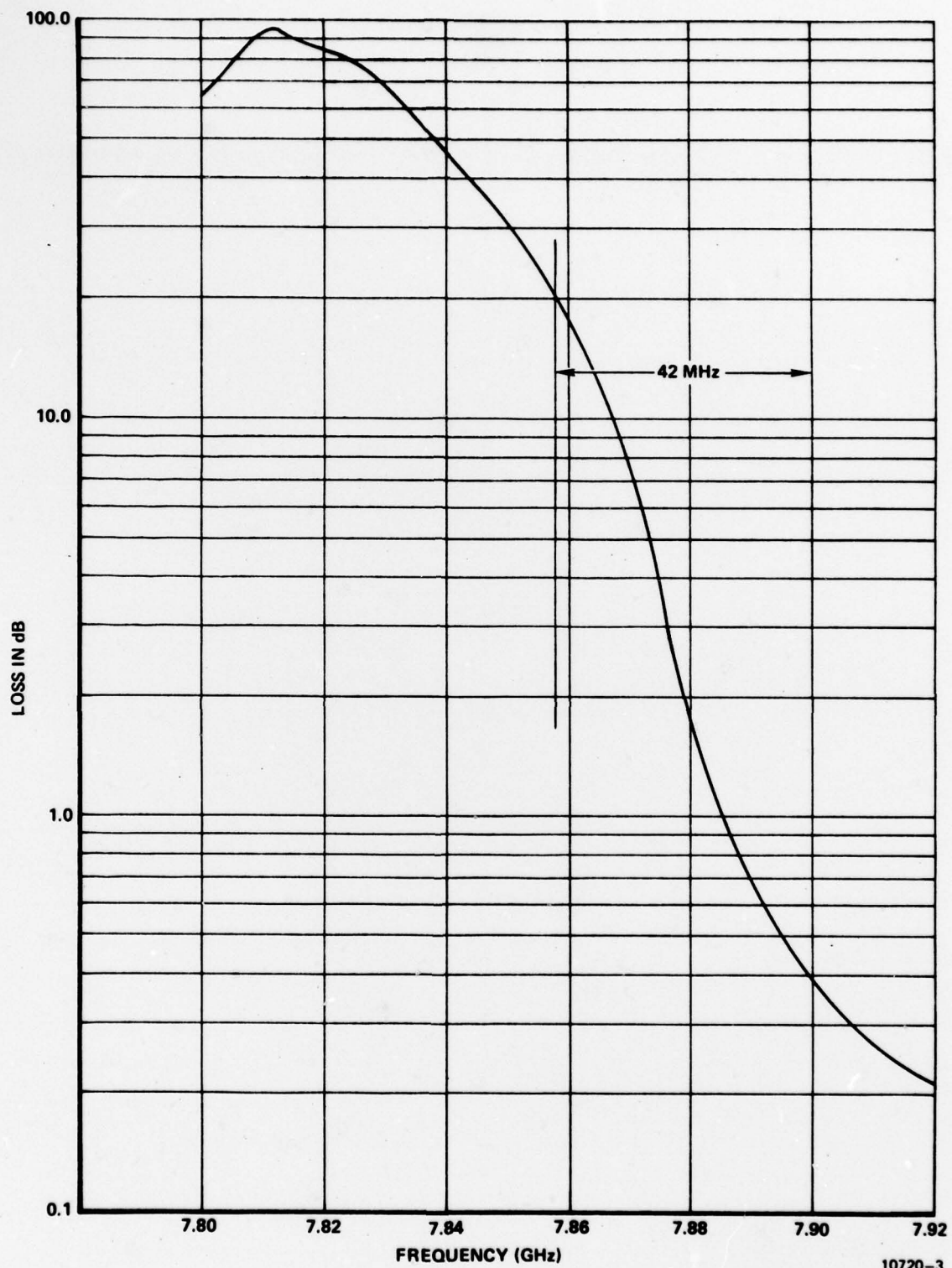
The FDMA and TDMA channels can be combined using a band stop filter design in the diplexer. For such a diplexer a band stop filter is substituted for the bandpass filter described in Paragraph 4.1. Referring again to Figure 2 the FDMA channels,  $F_L$

and  $F_H$ , enter port number 1 pass through the filters to port number 3. The TDMA channel enters port number 2, is reflected by the band stop filters into port number 3.

No calculated loss data is available for the exact band-stop filter requirement, but a band-stop filter of the same type was used in the HT terminals. A plot of this filter's loss as measured at Harris is shown in Figure 4. The rejection slope of the HT filter is about half of that required for this application since the guard band is only 25 MHz and the passband to 20 dB stop-band separation is only 42 MHz. The stop bandwidth of the HT filter is also about twice that required. Narrowing the stop bandwidth will increase the passband loss, especially at the band edges. A loss of approximately 0.7 dB at the band edges is predicted for this approach. This band edge loss occurs at the high end of FDMA Channel 6 and at the low end of FDMA Channel 2. The TDMA channel loss would be close to 0.1 dB.

#### 4.3 Dual E-Stub Wideband Band Stop Filter Diplexer Design

The combining function can be performed using dual E-stub wideband band stop filters in the diplexer design. Such a configuration is shown in Figure 5. It uses two diplexer sections. Each section uses broadband band stop E-stub filters to reduce passband losses. The first diplexer section separates the FDMA channels and combines the TDMA channel with FDMA Channel 6 in port number 3. FDMA Channel 2 passes through the filter into port number 4. The TDMA and FDMA Channels,  $F_T$  and  $F_L$ , enter port number 6 in the second section of the diplexer, pass through the filters and are combined with the FDMA Channel 2,  $F_H$ , in port number 8, the output port of the network. With this configuration the channel nearest the filter stop band (passband edge) is always the TDMA signal. The FDMA channels are either the reflected signals or are far from the filter band edges.



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Figure 4. Response of Band Stop Filter

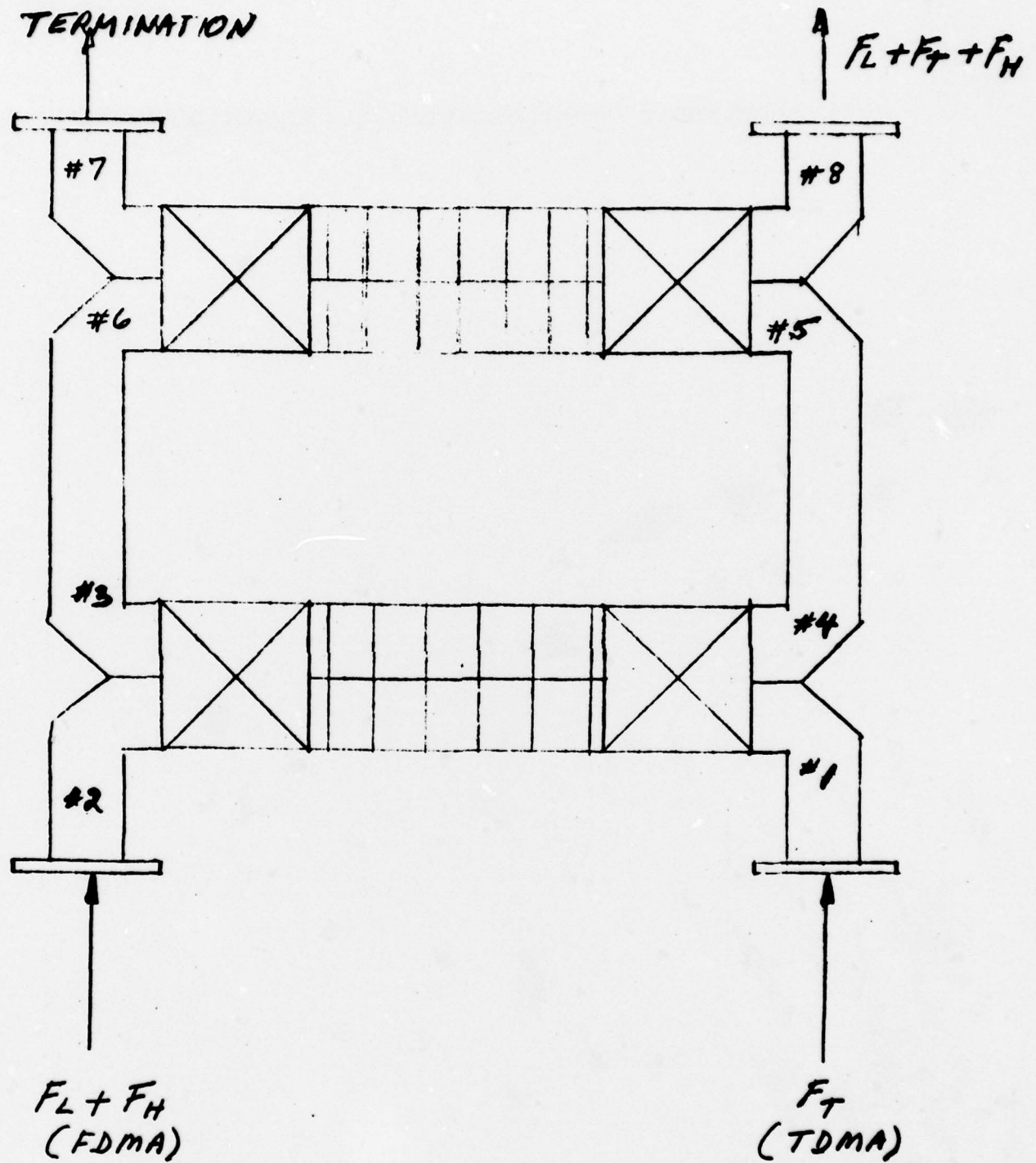


Figure 5. E-Stub Band Stop Filter Diplexer Configuration

Figure 6 is a sketch of a dual seven cavity, E-stub filter configuration used in an MT antenna diplexer application. This diplexer was designed to combine signal channels with a frequency separation of 50 MHz with an isolation greater than 60 dB. Although this diplexer was designed for 50 MHz frequency separation between channels which is twice the 25 MHz guard bands between the channels in the present application, test data indicated it would provide 25 dB isolation for a 25 MHz separation. The loss for reflected signals in this diplexer was 0.2 dB at band edge and dropped to 0.1 dB within 20 MHz of band edge. For signals passing through the filter the loss was 0.4 dB at band edge and dropped to 0.1 dB within 30 MHz. Losses could be reduced further by using a sharper cutoff (more stubs or longer stubs).

## 5.0 EVALUATION OF ALTERNATIVE DIPLEXER DESIGNS

The advantages and disadvantages of the three diplexer approaches discussed in Section 4.0 are briefly summarized below. The calculated loss curves for the three cases are shown in Figure 7.

### Band Pass Filter Approach

This is the most simple, straightforward, and lowest risk design approach. Computer programs exist for almost exact design. Highly accurate loss, VSWR and phase characteristics can be computed. However, this design has unacceptably high losses in the TDMA channel when implemented in WR 137 waveguide. The loss at the TDMA band center can be reduced to 0.5 dB or slightly less if a  $TE_{011}$  cylindrical cavity design filter is used. The loss to FDMA channels is the lowest (0.1 dB) of the three approaches considered.

### Band Stop Filter Approach

This approach provides the lowest loss to the TDMA channel but the highest loss to the FDMA channels. This filter is relatively simple in design although not quite as straightforward as the bandpass design.

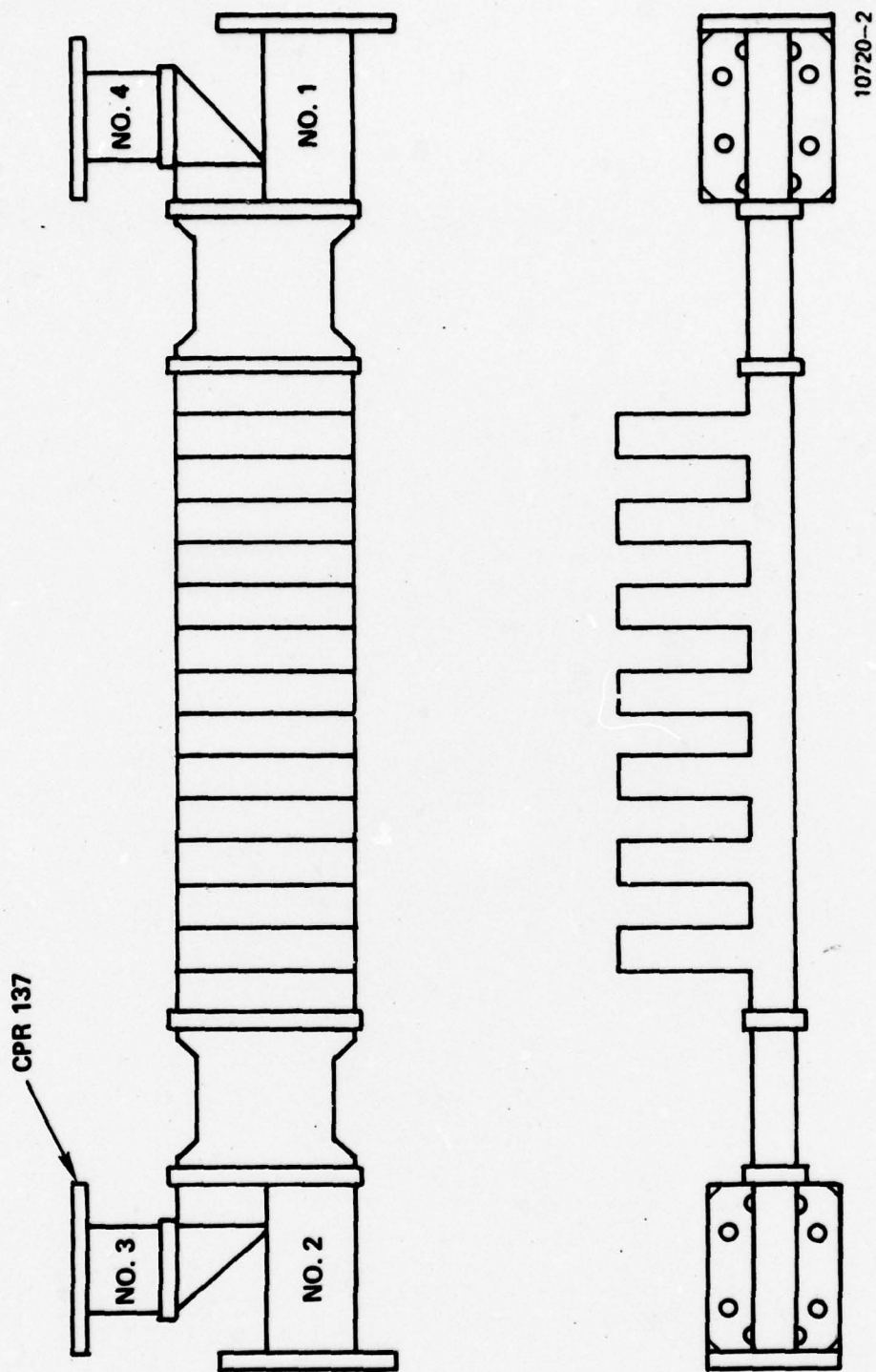


Figure 6. Seven Cavity E-Stub Filter

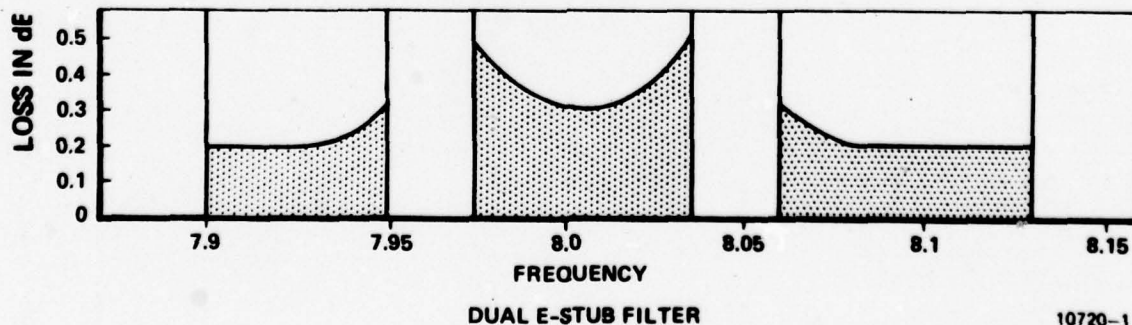
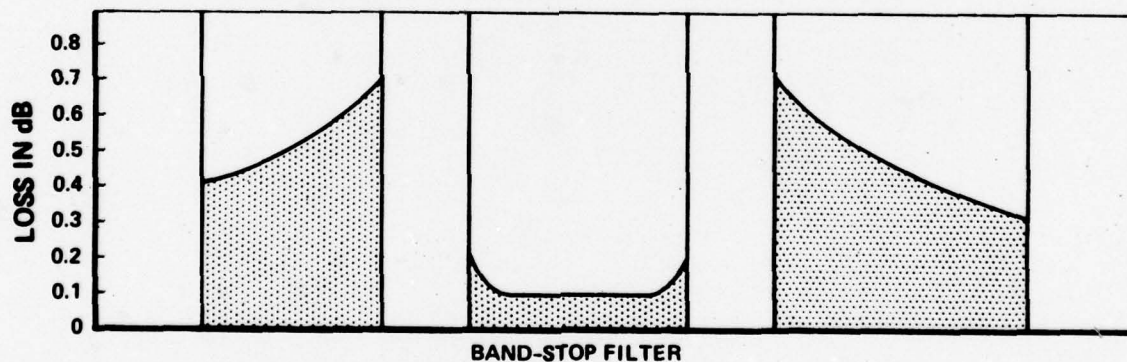
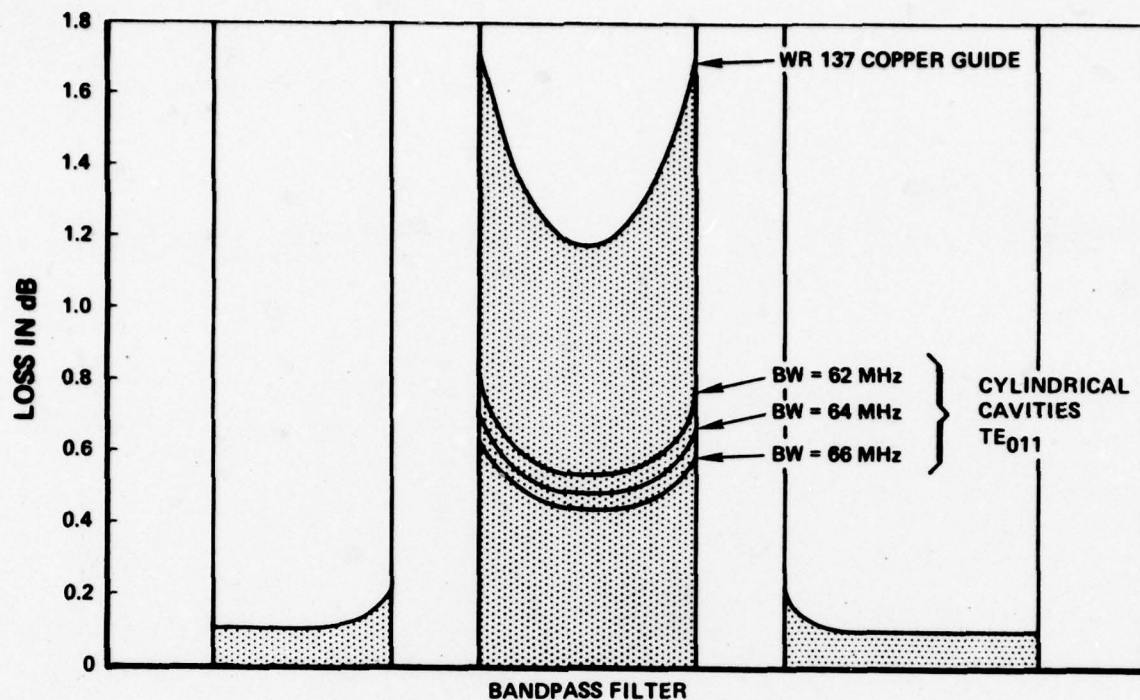


Figure 7. Calculated Losses for the Three Alternative Diplexer Filter Approaches

### Dual E-Stub Band Stop Filter Approach

This is the most complex of the three filter approaches. Two filter sections are required which doubles the number of components and more than doubles the diplexer space requirement. This approach provides somewhat lower loss to the TDMA channel than can be achieved with the bandpass filter approach and provides lower loss to the FDMA channels than the bandstop filter case.

In making a final tradeoff on the choice of diplexer approach some consideration should be given to the weight to be given the various channel losses. Is achieving lower losses more important in the TDMA channel or in the FDMA channels?

For the application being considered, a TDMA transmitter is being added as a modification to an existing terminal. Non-TDMA channels should be degraded as little as possible. Specifically, the terminal EIRP and therefore AJ capability should be impacted as little as possible.

After considering the loss calculations presented in Figure 6, along with other factors discussed above, it appears that the band stop filter approach discussed in Paragraph 4.2 can be eliminated based on the relatively high losses in the non-TDMA channels. This diplexer approach would present minimum losses of 0.3 to 0.4 dB for all portions of the 7.9 to 8.4 GHz uplink band except for the TDMA channel where losses would be very low.

The choice is then between the bandpass and the E-stub filter diplexer approaches. As previously stated the bandpass filter approach provides the least losses to non-TDMA channels, 0.1 dB versus 0.2 dB minimum losses. However, the minimum loss at the TDMA channel band center will be somewhat higher for the bandpass filter approach. Using  $TE_{011}$  cylindrical cavities with a bandwidth of 66 MHz a minimum loss between 0.4 and 0.5 dB can be achieved for the TDMA channel using the bandpass filter approach. This loss can be reduced to about 0.3 dB using the E-stub filter approach.

The bandpass filter diplexer approach is chosen over the E-stub filter approach. The slightly lower loss provided to the TDMA channel by the E-stub filter approach is outweighed by the lower loss in non-TDMA bands and by the simplicity, and smaller size of the bandpass filter diplexer approach.

## 6.0 CONCLUSIONS

Design approaches for a diplexer to combine FDMA and TDMA channel signals for simultaneous transmission in the DSCS Phase III Satellite have been evaluated. The scope of this study task limited the evaluation to diplexer approaches for which Harris has had previous design experience.

A diplexer approach based on the use of bandpass filters using  $TE_{011}$  cylindrical cavities has been presented. This approach allows the combining of FDMA and TDMA signals with low loss (0.1 dB) to non-TDMA channels and only moderate loss (0.4 to 0.5 dB at band center) to the TDMA channel. The effects on phase linearity are negligible for all channels. Based on the simplicity of the design approach presented it is concluded that the costs and risk associated with the diplexer will be negligible factors in any TDMA transmitter modifications to the AN/FSC-78 or AN/MSC-61 terminals.

## APPENDIX A

Computer analysis for a cylindrical 5-cavity  $TE_{011}$  Tchebyscheff

0.04 dB ripple bandpass filter for the following passbands:

- |    |                    |            |
|----|--------------------|------------|
| 1. | 7.973 to 8.037 GHz | BW= 64 MHz |
| 2. | 7.972 to 8.038 GHz | BW= 66 MHz |
| 3. | 7.974 to 8.036 GHz | BW= 62 MHz |

# FILTER DESIGN

## LOCK TONGUE FILTER

.0000 DB LOSS POINT		5 CAVITIES		.0000 DB RIPPLE		TCHUTSCHOFF FILTER	
ORIGINAL	F1 = 7975.00000	F2 = 8037.00000	BANDWIDTH =	64.00000	FU = 8004.75419		
CORRECTED	F1 = 7975.00000	F2 = 8037.00000	BANDWIDTH =	64.00000	FC = 8301.53163		
A = 1.37286		H = .62200000	I = .05040	L = 1.00000			
QJ = 10000.00000		R = 1.00000000	M = .02460	CLB = .00000			
OMEGA-PR = 1.00000		DTOL = .00500000	LV = 0.00000	RND = 0.00000			
DESIGN CHARACTERISTICS		LARGA-60/4 = .447081 INCHES		= 1.110167 CM.			
G		U		CAVITY LENGTH (CL)			
.0177		1.2207		.3272			
.9576		64.8640		.0674			
1.3704		60.6314		.1679			
1.7875		60.6314		.0674			
1.3704		64.8640		.3272			
.9576		1.2207		0.0000			
.0177		0.0000		0.0000			
PRACTICAL DESIGN DIMENSIONS		SUSCEPTANCE FOR THE SYMMETRIC VANE.					
CAVITY LENGTH (CL)		GAP WIDTH (G)		B1		DELTA L	
.06319		.3095246		27.01207		.01000	
.90401		.1054153		67.41165		.00415	
.90568		.1671902		77.21903		.00360	

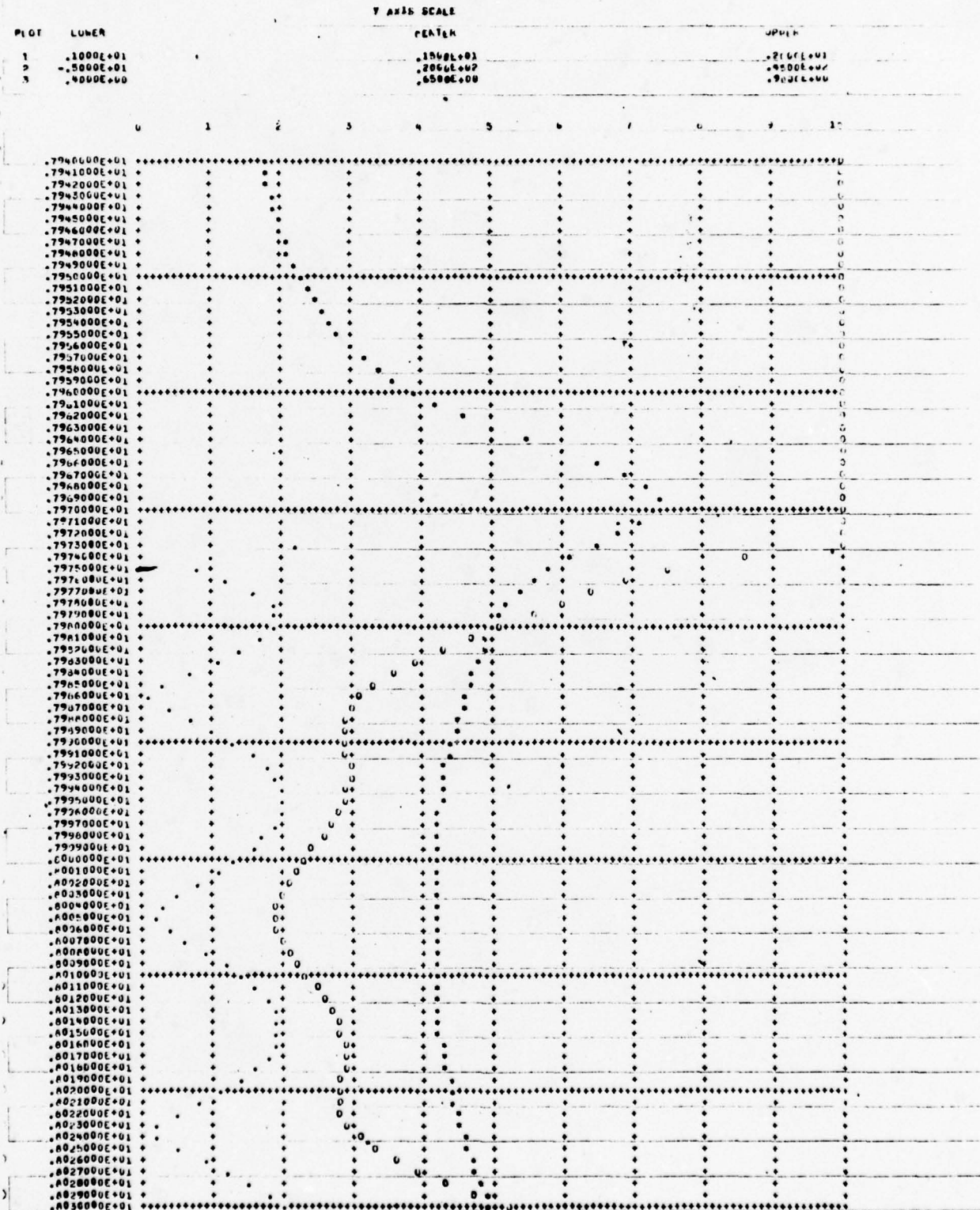
## FILTER DESIGN - ANALYSIS OUTPUT

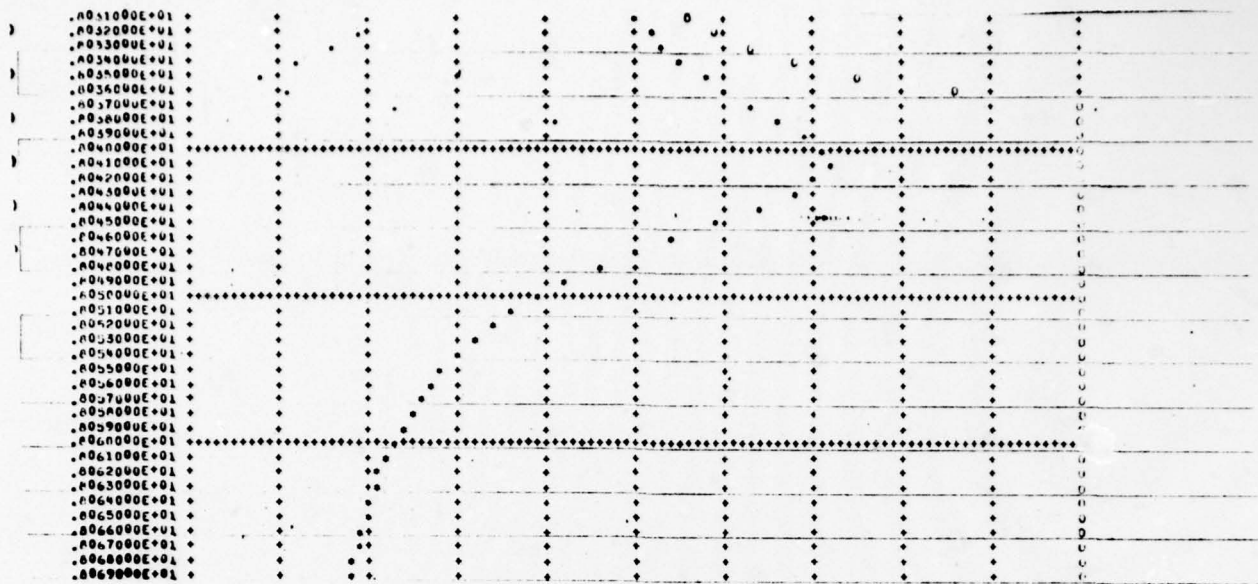
FREQUENCY	INSERTION LOSS	INSERTION PHASE	GAMMA(DB)	ANG VALUE	ANGLE OF GAMMA	STANDING WAVE RATIO	GROUP DELAY (NS)	DISPERSTO.
.7940000E+01	32.2019	352.8050	-.0066	.970014	100.00620	59.0000	.3761600E+01	-.1399400E+02
.7941000E+01	31.4166	354.1900	-.0713	.969545	96.60382	59.0000	.3534670E+01	-.1396470E+02
.7942000E+01	30.6190	355.6396	-.0765	.968992	97.29997	59.0000	.4110654E+01	-.1393574E+02
.7943000E+01	29.8044	357.1508	-.1023	.968296	95.04399	59.0000	.4002261E+01	-.1390641E+02
.7944000E+01	28.9715	358.7537	-.1067	.967545	94.32076	59.0000	.4541630E+01	-.1387159E+02
.7945000E+01	28.1204	360.4307	-.1150	.966752	92.72806	59.0000	.4770724E+01	-.1383777E+02
.7946000E+01	27.2502	362.1978	-.1239	.965926	91.04421	59.0000	.5050422E+01	-.1380400E+02
.7947000E+01	26.3599	364.0613	-.1331	.965079	89.26877	59.0000	.5362964E+01	-.1377028E+02
.7948000E+01	25.4426	366.0329	-.1435	.964216	87.38755	59.0000	.5690771E+01	-.1373661E+02
.7949000E+01	24.5151	368.1240	-.1555	.963239	85.39443	59.0000	.6035301E+01	-.1370294E+02
.7950000E+01	23.5584	370.3436	-.1680	.962250	83.24106	59.0000	.6396724E+01	-.1366927E+02
.7951000E+01	22.5773	372.7097	-.1810	.961253	81.02113	59.0000	.6775024E+01	-.1363560E+02
.7952000E+01	21.5706	375.2362	-.1952	.960250	78.72158	59.0000	.7169204E+01	-.1360193E+02
.7953000E+01	20.5369	377.9486	-.2103	.959246	76.34240	59.0000	.7578264E+01	-.1356826E+02
.7954000E+01	19.4752	380.8644	-.2263	.958243	73.88755	59.0000	.8001204E+01	-.1353459E+02
.7955000E+01	18.3893	384.0131	-.2430	.957243	71.36243	59.0000	.8437924E+01	-.1350092E+02
.7956000E+01	17.2832	387.4272	-.2603	.956246	68.78103	59.0000	.8888324E+01	-.1346725E+02
.7957000E+01	16.1612	391.1458	-.2783	.955253	66.14989	59.0000	.9352324E+01	-.1343358E+02
.7958000E+01	15.0285	395.2151	-.2969	.954266	63.48362	59.0000	.9829824E+01	-.1340000E+02
.7959000E+01	13.8790	399.6903	-.3160	.953286	60.78755	59.0000	.1.032072E+02	-.1336641E+02
.7960000E+01	12.7173	404.6372	-.3356	.952313	58.06740	59.0000	.1.082492E+02	-.1333282E+02
.7961000E+01	11.5486	410.1312	-.3557	.951348	55.32755	59.0000	.1.134232E+02	-.1330000E+02
.7962000E+01	9.2771	416.2503	-.3763	.950393	52.58362	59.0000	.1.187282E+02	-.1326717E+02
.7963000E+01	6.9412	423.1104	-.3973	.949448	49.83103	59.0000	.1.241632E+02	-.1323434E+02
.7964000E+01	7.7669	430.7763	-.4187	.948513	47.07440	59.0000	.1.297282E+02	-.1320151E+02
.7965000E+01	6.1359	439.3255	-.4405	.947588	44.31875	59.0000	.1.354232E+02	-.1316868E+02
.7966000E+01	4.9752	448.7711	-.4627	.946673	41.56840	59.0000	.1.412482E+02	-.1313585E+02
.7967000E+01	3.9247	459.0550	-.4853	.945768	38.82755	59.0000	.1.471932E+02	-.1310302E+02
.7968000E+01	3.0206	470.0072	-.5083	.944873	36.09103	59.0000	.1.532582E+02	-.1307019E+02
.7969000E+01	2.2806	481.3507	-.5317	.943988	33.36240	59.0000	.1.594432E+02	-.1303736E+02
.7970000E+01	1.7340	492.7579	-.5555	.943113	30.63755	59.0000	.1.657482E+02	-.1300453E+02
.7971000E+01	1.3429	505.9220	-.5797	.942248	27.92103	59.0000	.1.721732E+02	-.1297170E+02
.7972000E+01	1.0653	519.6214	-.6043	.941393	25.20740	59.0000	.1.787182E+02	-.1293887E+02
.7973000E+01	.8259	524.7436	-.6293	.940548	22.50103	59.0000	.1.853832E+02	-.1290604E+02
.7974000E+01	.6319	534.2707	-.6547	.939713	19.80640	59.0000	.1.921682E+02	-.1287321E+02
.7975000E+01	.4772	543.2459	-.6805	.938888	17.12755	59.0000	.1.990732E+02	-.1284038E+02
.7976000E+01	.3536	551.7425	-.7067	.938073	14.56840	59.0000	.2.060982E+02	-.1280755E+02
.7977000E+01	.2599	559.8411	-.7333	.937268	12.13362	59.0000	.2.132432E+02	-.1277472E+02
.7978000E+01	.1900	567.6160	-.7603	.936473	9.81875	59.0000	.2.205082E+02	-.1274189E+02
.7979000E+01	.1402	575.1337	-.7877	.935688	7.62755	59.0000	.2.278932E+02	-.1270906E+02
.7980000E+01	.1066	582.4424	-.8155	.934913	5.55640	59.0000	.2.353982E+02	-.1267623E+02
.7981000E+01	.0837	589.5816	-.8437	.934148	3.60103	59.0000	.2.430232E+02	-.1264340E+02
.7982000E+01	.0673	596.5784	-.8723	.933393	1.76640	59.0000	.2.507682E+02	-.1261057E+02
.7983000E+01	.0543	603.4521	-.9013	.932648	0.00000	59.0000	.2.586332E+02	-.1257774E+02
.7984000E+01	.0449	610.2142	-.9307	.931913	24.05700	59.0000	.2.666182E+02	-.1254491E+02
.7985000E+01	.0379	616.8726	-.9605	.931188	25.10995	59.0000	.2.747232E+02	-.1251208E+02
.7986000E+01	.0324	623.4319	-.9907	.930473	171.49577	59.0000	.2.829482E+02	-.1247925E+02
.7987000E+01	.0284	629.8937	-.1.0213	.929768	144.22500	59.0000	.2.912932E+02	-.1244642E+02
.7988000E+01	.0253	636.2673	-.1.0523	.929073	167.50440	59.0000	.2.997582E+02	-.1241359E+02
.7989000E+01	.0230	642.5506	-.1.0837	.928388	163.51500	59.0000	.3.083432E+02	-.1238076E+02
.7990000E+01	.0214	648.7507	-.1.1155	.927713	150.67270	59.0000	.3.170482E+02	-.1234793E+02
.7991000E+01	.0202	654.8755	-.1.1477	.927048	130.52410	59.0000	.3.258732E+02	-.1231510E+02
.7992000E+01	.0192	660.9263	-.1.1803	.926393	100.25319	59.0000	.3.348182E+02	-.1228227E+02
.7993000E+01	.0184	666.9173	-.1.2133	.925748	142.94994	59.0000	.3.438832E+02	-.1224944E+02
.7994000E+01	.0177	672.8547	-.1.2467	.925113	137.65242	59.0000	.3.530682E+02	-.1221661E+02
.7995000E+01	.0171	678.7475	-.1.2805	.924488	132.39270	59.0000	.3.623732E+02	-.1218378E+02
.7996000E+01	.0166	684.6000	-.1.3147	.923873	127.17961	59.0000	.3.717982E+02	-.1215095E+02
.7997000E+01	.0162	690.4324	-.1.3493	.923268	122.00615	59.0000	.3.813432E+02	-.1211812E+02
.7998000E+01	.0158	696.2399	-.1.3843	.922673	117.10963	59.0000	.3.910082E+02	-.1208529E+02
.7999000E+01	.0155	702.0311	-.1.4197	.922088	112.33462	59.0000	.4.007932E+02	-.1205246E+02
.8000000E+01	.0153	707.8125	-.1.4555	.921513	107.64441	59.0000	.4.106982E+02	-.1201963E+02
.8001000E+01	.0151	713.5870	-.1.4917	.920948	103.01400	59.0000	.4.207232E+02	-.1198680E+02
.8002000E+01	.0149	719.3572	-.1.5283	.920393	101.32901	59.0000	.4.308682E+02	-.1195397E+02

A0010000E+01	4985	725.1245	-81.6151	082664	101.67254	1.0550	10010000E+02	-1.780000E+01
A0020000E+01	4986	730.8490	-87.2913	082669	112.79160	1.0477	10010000E+02	-1.780000E+01
A0030000E+01	4958	736.6510	-91.9005	082672	123.62801	1.0468	10010000E+02	-1.780000E+01
A0040000E+01	4966	742.9116	-36.0015	082675	223.18662	1.0379	10010000E+02	-1.780000E+01
A0050000E+01	4996	748.1646	-38.0505	082678	224.16170	1.0449	10010000E+02	-1.780000E+01
A0060000E+01	5042	753.9233	-27.1431	082681	225.07145	1.0519	10010000E+02	-1.780000E+01
A0070000E+01	5108	759.6765	-25.1149	082684	226.00229	1.1177	10010000E+02	-1.780000E+01
A0080000E+01	5164	765.4302	-23.6479	082687	227.07346	1.1407	10010000E+02	-1.780000E+01
A0090000E+01	5230	771.1874	-22.3693	082690	228.09509	1.1607	10010000E+02	-1.780000E+01
A0100000E+01	5295	776.9503	-21.0907	082693	229.09668	1.1768	10010000E+02	-1.780000E+01
A0110000E+01	5367	782.7300	-20.0000	082696	230.09828	1.1861	10010000E+02	-1.780000E+01
A0120000E+01	5396	788.5274	-21.0369	082699	231.09987	1.1957	10010000E+02	-1.780000E+01
A0130000E+01	5419	794.3512	-21.0367	082702	232.10146	1.1957	10010000E+02	-1.780000E+01
A0140000E+01	5483	800.2097	-21.2524	082705	233.10305	1.1957	10010000E+02	-1.780000E+01
A0150000E+01	5435	806.1118	-21.7276	082708	234.10464	1.1957	10010000E+02	-1.780000E+01
A0160000E+01	5427	812.0642	-22.5024	082711	235.10623	1.1957	10010000E+02	-1.780000E+01
A0170000E+01	5415	818.0792	-23.6412	082714	236.10782	1.1957	10010000E+02	-1.780000E+01
A0180000E+01	5405	824.1510	-25.3359	082717	237.10941	1.1957	10010000E+02	-1.780000E+01
A0190000E+01	5406	830.3000	-27.0153	082720	238.11100	1.1957	10010000E+02	-1.780000E+01
A0200000E+01	5423	836.5059	-31.0194	082723	239.11259	1.1957	10010000E+02	-1.780000E+01
A0210000E+01	5467	842.8330	-40.2216	082726	240.11418	1.1957	10010000E+02	-1.780000E+01
A0220000E+01	5500	849.2241	-40.9408	082729	241.11577	1.1957	10010000E+02	-1.780000E+01
A0230000E+01	5568	855.7022	-31.7752	082732	242.11736	1.1957	10010000E+02	-1.780000E+01
A0240000E+01	5790	862.2705	-27.0465	082735	243.11895	1.1957	10010000E+02	-1.780000E+01
A0250000E+01	5962	868.9381	-24.7115	082738	244.12054	1.1957	10010000E+02	-1.780000E+01
A0260000E+01	6159	875.7011	-27.0091	082741	245.12213	1.1957	10010000E+02	-1.780000E+01
A0270000E+01	6367	882.5044	-21.6903	082744	246.12372	1.1957	10010000E+02	-1.780000E+01
A0280000E+01	6577	889.6086	-21.0142	082747	247.12531	1.1957	10010000E+02	-1.780000E+01
A0290000E+01	6781	896.7676	-20.0540	082750	248.12690	1.1957	10010000E+02	-1.780000E+01
A0300000E+01	6975	904.1790	-21.2855	082753	249.12849	1.1957	10010000E+02	-1.780000E+01
A0310000E+01	7171	911.8133	-22.5145	082756	250.13008	1.1957	10010000E+02	-1.780000E+01
A0320000E+01	7403	919.7669	-24.9453	082759	251.13167	1.1957	10010000E+02	-1.780000E+01
A0330000E+01	7737	926.1036	-26.3762	082802	252.13326	1.1957	10010000E+02	-1.780000E+01
A0340000E+01	8291	936.9034	-25.7937	082805	253.13485	1.1957	10010000E+02	-1.780000E+01
A0350000E+01	9241	946.2247	-19.5355	082808	254.13644	1.1957	10010000E+02	-1.780000E+01
A0360000E+01	10835	956.1039	-15.3052	082811	255.13803	1.1957	10010000E+02	-1.780000E+01
A0370000E+01	13374	966.5177	-11.0450	082814	256.13962	1.1957	10010000E+02	-1.780000E+01
A0380000E+01	17113	977.3564	-9.1334	082817	257.14121	1.1957	10010000E+02	-1.780000E+01
A0390000E+01	22528	988.4150	-6.9456	082820	258.14280	1.1957	10010000E+02	-1.780000E+01
A0400000E+01	29542	999.4115	-5.3027	082823	259.14439	1.1957	10010000E+02	-1.780000E+01
A0410000E+01	38171	1010.0459	-4.0067	082826	260.14598	1.1957	10010000E+02	-1.780000E+01
A0420000E+01	48190	1020.0650	-3.0272	082829	261.14757	1.1957	10010000E+02	-1.780000E+01
A0430000E+01	54274	1029.3050	-2.2964	082832	262.14916	1.1957	10010000E+02	-1.780000E+01
A0440000E+01	71074	1037.6996	-1.7613	082835	263.15075	1.1957	10010000E+02	-1.780000E+01
A0450000E+01	83288	1045.2579	-1.3647	082838	264.15234	1.1957	10010000E+02	-1.780000E+01
A0460000E+01	95647	1052.0365	-1.0761	082841	265.15393	1.1957	10010000E+02	-1.780000E+01
A0470000E+01	108000	1058.1148	-0.8606	082844	266.15552	1.1957	10010000E+02	-1.780000E+01
A0480000E+01	126217	1063.5765	-0.6956	082847	267.15711	1.1957	10010000E+02	-1.780000E+01
A0490000E+01	152221	1068.3024	-0.5777	082850	268.15870	1.1957	10010000E+02	-1.780000E+01
A0500000E+01	183967	1072.9644	-0.4842	082853	269.16029	1.1957	10010000E+02	-1.780000E+01
A0510000E+01	225429	1077.0234	-0.4117	082856	270.16188	1.1957	10010000E+02	-1.780000E+01
A0520000E+01	285599	1080.7307	-0.3546	082859	271.16347	1.1957	10010000E+02	-1.780000E+01
A0530000E+01	374744	1084.1497	-0.3092	082902	272.16506	1.1957	10010000E+02	-1.780000E+01
A0540000E+01	496058	1087.2944	-0.2745	082905	273.16665	1.1957	10010000E+02	-1.780000E+01
A0550000E+01	656361	1090.2111	-0.2425	082908	274.16824	1.1957	10010000E+02	-1.780000E+01
A0560000E+01	86392	1092.9209	-0.2177	082911	275.16983	1.1957	10010000E+02	-1.780000E+01
A0570000E+01	116162	1095.4489	-0.1970	082914	276.17142	1.1957	10010000E+02	-1.780000E+01
A0580000E+01	157682	1097.8148	-0.1795	082917	277.17301	1.1957	10010000E+02	-1.780000E+01
A0590000E+01	216964	1100.0334	-0.1644	082920	278.17460	1.1957	10010000E+02	-1.780000E+01
A0600000E+01	296018	1102.1250	-0.1518	082923	279.17619	1.1957	10010000E+02	-1.780000E+01
A0610000E+01	40856	1104.0964	-0.1406	082926	280.17778	1.1957	10010000E+02	-1.780000E+01
A0620000E+01	563487	1105.9604	-0.1309	082929	281.17937	1.1957	10010000E+02	-1.780000E+01
A0630000E+01	771922	1107.7265	-0.1223	082932	282.18096	1.1957	10010000E+02	-1.780000E+01
A0640000E+01	106168	1109.4081	-0.1147	082935	283.18255	1.1957	10010000E+02	-1.780000E+01
A0650000E+01	142235	1110.9976	-0.1079	082938	284.18414	1.1957	10010000E+02	-1.780000E+01
A0660000E+01	194131	1112.0165	-0.1018	082941	285.18573	1.1957	10010000E+02	-1.780000E+01
A0670000E+01	263862	1113.9636	-0.0963	082944	286.18732	1.1957	10010000E+02	-1.780000E+01

LOW PASS FILTER  
FILTER DESIGN PLOTS

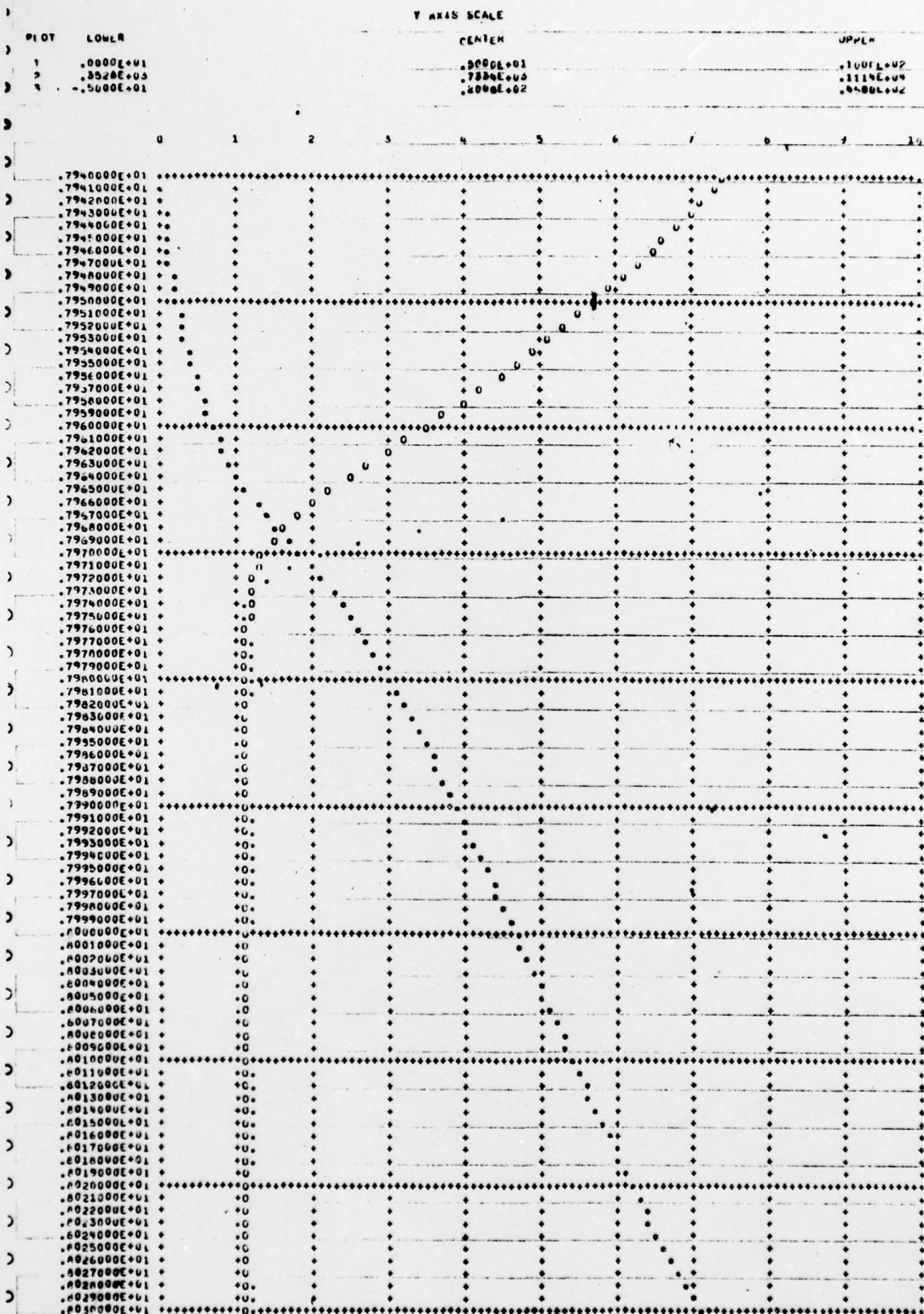
STANDING WAVE RATIO AND TIME DELAY VS FREQUENCY  
SYMBOL FOR GRAPH 1 (STANDING WAVE RATIO VS FREQUENCY) = \*  
SYMBOL FOR GRAPH 2 (TIME DELAY VS FREQUENCY) = o  
SYMBOL FOR GRAPH 3 (INSERTION LOSS VS FREQUENCY) = 0

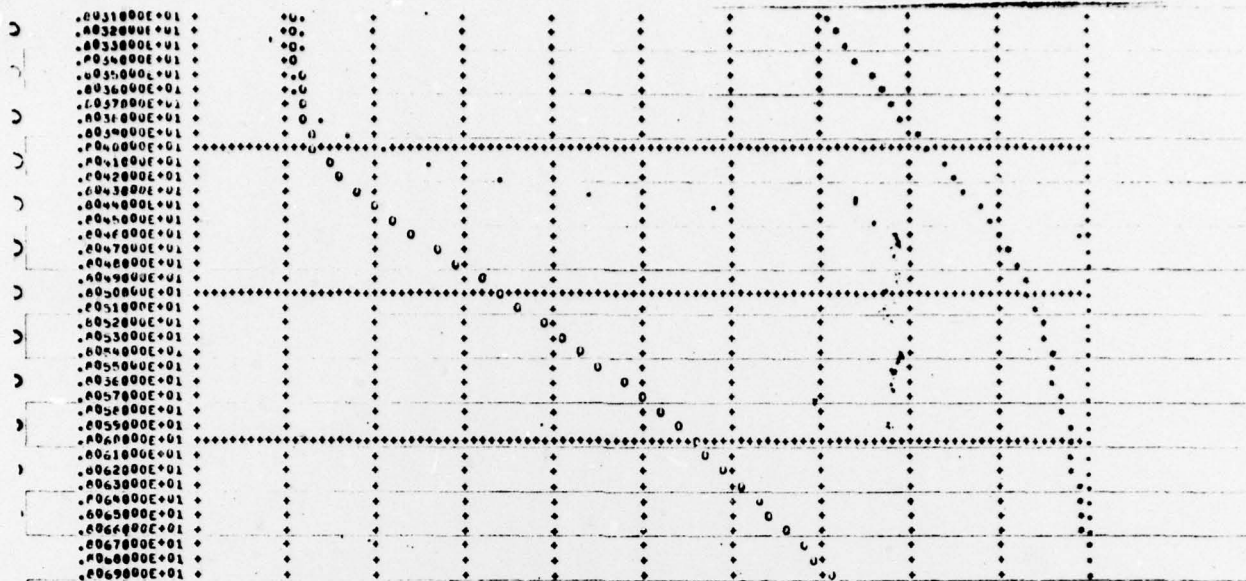




LOCK TUNING FILTER  
FILTER DESIGN PLOTS

SYMBOL FOR GRAPH 1 (STANDING WAVE RATIO VS FREQUENCY) = \*  
SYMBOL FOR GRAPH 2 (INSERTION PHASE VS FREQUENCY) = O  
SYMBOL FOR GRAPH 3 (INSERTION LOSS VS FREQUENCY) = .





# FILTER DESIGN

## LOCK YOUNG FILTER

.0000 DB LOSS POINT

5 CAVITIES

.00000 DB RIFPLE

10MUTSCHEFF FILTER

ORIGINAL F1 = 7972.00000  
CORRECTED F1 = 7972.00000

F2 = 0030.00000  
F2 = 0030.00000

BANDWIDTH = 0.00000  
BANDWIDTH = 00.00000

F0 = 0004.7112  
FC = 0004.7112

A = 1.37200  
QJ = 10000.00000  
OMEGA-PA = 1.00000

B = .022000000  
H = 1.000000000  
OTOL = .005000000

I = .05000  
M = .02200  
LU = 0.00000

E = 1.00000  
CL = .00500  
RM = 0.00000

## DESIGN CHARACTERISTICS

LAMDA-00/4 =

.437002 INCHES

= 1.110109 CM

6  
.0102  
.9076  
1.3704  
1.7075  
1.8704  
.9076  
.0102

8  
7.1101  
68.0976  
69.0000  
69.9000  
68.0976  
7.1101  
0.0000

CAVITY LENGTH (CL)  
.03161  
.06651  
.06769  
.06651  
.03161  
0.00000  
0.00000

## PRACTICAL DESIGN DIMENSIONS

SUSCEPTANCE FOR THE STANDING WAVE.

CAVITY LENGTH (CL)  
.06237  
.90307  
.90539

GAP WIDTH (G)  
.3716596  
.1073327  
.1600950

SUSCEPTANCE (H)  
1.15720  
01.86261  
03.76105

U1  
27.64940  
60.52017  
76.10020

DELTA L  
0.1000  
0.0010  
0.0050

## FILTER DESIGN - ANALYSIS OUTPUT

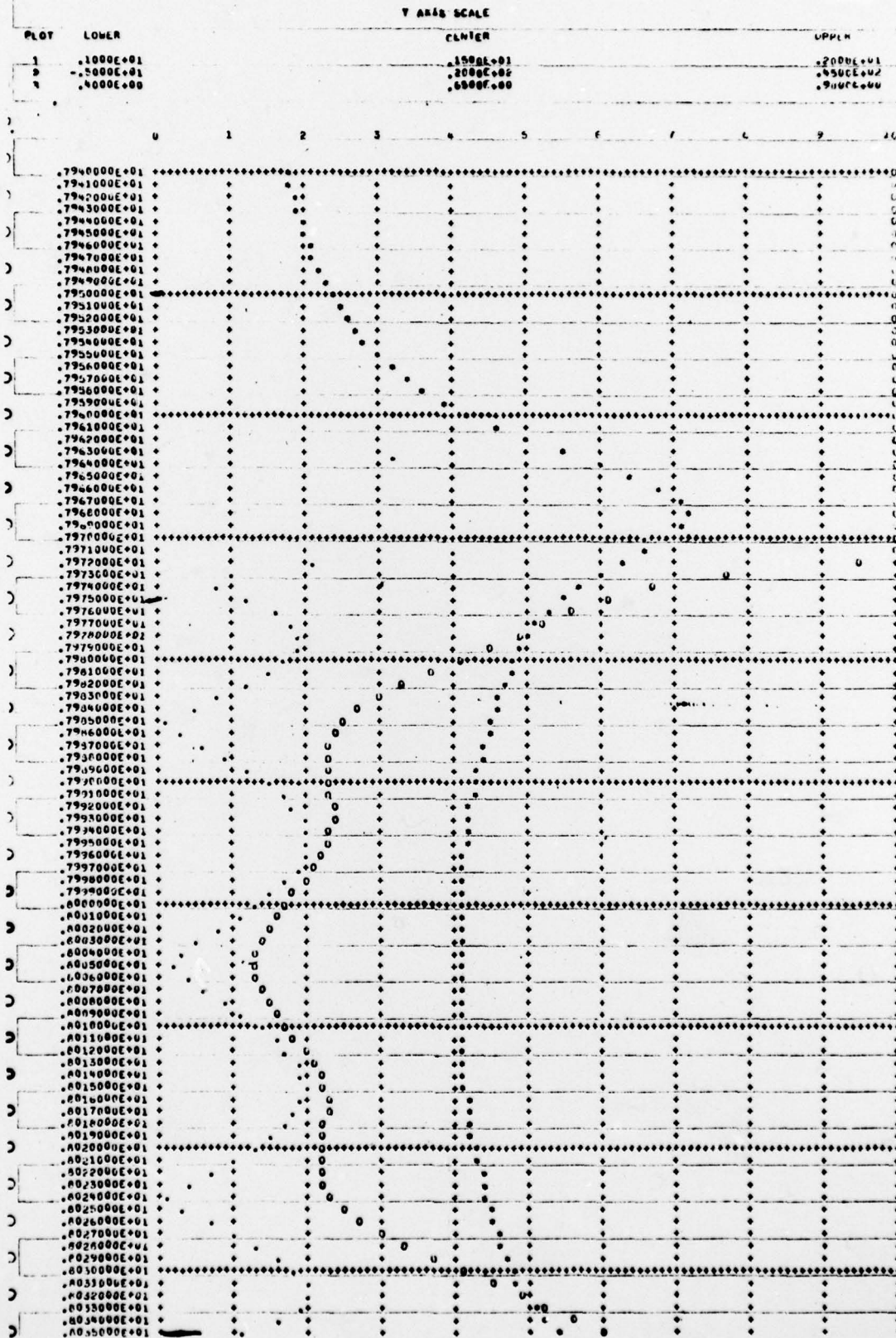
## LOCK YOUNG FILTER

FREQUENCY	INSERTION LOSS	INSERTION PHASE	GAMMA(DBI)	ABS VALUE OF GAMMA	ANGLE OF GAMMA	STANDING WAVE RATIO	GROUP DELAY (NS)	DISPERSION
.7900000E+01	30.6526	355.6130	-.0907	.989007	97.14900	59.0000	.8901000E+01	-.1347000E+02
.7910000E+01	29.0619	357.0795	-.0900	.989003	95.70503	59.0000	.8100500E+01	-.1320000E+02
.7920000E+01	29.0549	350.6163	-.1019	.980000	90.27521	59.0000	.6072000E+01	-.1200000E+02
.7930000E+01	28.2308	360.2296	-.1004	.967596	92.73190	59.0000	.4050000E+01	-.1000000E+02
.7940000E+01	27.3000	361.9200	-.1157	.967000	91.10951	59.0000	.4020000E+01	-.1200000E+02
.7950000E+01	26.5200	363.7129	-.1240	.955000	89.40183	59.0000	.5000000E+01	-.1000000E+02
.7960000E+01	25.6475	365.5900	-.1335	.900000	87.59059	59.0000	.5000000E+01	-.1000000E+02
.7970000E+01	24.7404	367.5932	-.1442	.903500	85.69070	59.0000	.5000000E+01	-.1000000E+02
.7980000E+01	23.8236	369.7073	-.1566	.902100	84.67324	59.0000	.6000000E+01	-.1100000E+02
.7990000E+01	22.9701	371.9500	-.1711	.900000	81.52799	59.0000	.6000000E+01	-.1100000E+02
.7900000E+01	21.9007	374.3479	-.1801	.970000	79.20217	52.0000	.6000000E+01	-.1000000E+02
.7910000E+01	20.9104	376.9059	-.2004	.970000	71.00000	53.0000	.7000000E+01	-.1000000E+02
.7920000E+01	19.6939	379.6400	-.2307	.970000	70.10012	70.0000	.7000000E+01	-.1000000E+02
.7930000E+01	18.0000	382.5900	-.2621	.970000	71.37037	60.0000	.8000000E+01	-.1000000E+02
.7940000E+01	17.7703	385.7000	-.2933	.960000	60.33300	50.0000	.9000000E+01	-.1000000E+02
.7950000E+01	16.6655	389.2393	-.3433	.961000	63.00110	50.0000	.1000000E+02	-.1000000E+02
.7960000E+01	15.5312	393.0014	-.4000	.950000	61.45770	40.0000	.1000000E+02	-.1000000E+02
.7970000E+01	14.3676	397.1122	-.4720	.947000	57.93293	30.0000	.1000000E+02	-.1000000E+02
.7980000E+01	13.1700	401.6410	-.5600	.930000	50.20000	20.0000	.1000000E+02	-.1000000E+02
.7990000E+01	11.9590	406.6695	-.6607	.925000	46.40573	10.0000	.1000000E+02	-.1000000E+02
.7900000E+01	10.7214	412.1035	-.8515	.900000	43.21001	00.0000	.1000000E+02	-.1000000E+02
.7910000E+01	9.4713	418.5567	-.1.0099	.800000	37.50000	10.0000	.1000000E+02	-.1000000E+02
.7920000E+01	8.2214	425.2940	-.1.2057	.600000	30.00001	30.0000	.1000000E+02	-.1000000E+02
.7930000E+01	6.9904	432.9246	-.1.7000	.615000	23.59414	50.0000	.1000000E+02	-.1000000E+02
.7940000E+01	5.8038	441.4523	-.2.3169	.705000	15.57077	70.0000	.1000000E+02	-.1000000E+02
.7950000E+01	4.6535	450.8704	-.3.0005	.702000	0.00000	90.0000	.1000000E+02	-.1000000E+02
.7960000E+01	3.6952	460.9005	-.4.0710	.625000	357.90000	0.0000	.1000000E+02	-.1000000E+02
.7970000E+01	2.8413	471.7259	-.5.4014	.350000	247.66694	30.0000	.1000000E+02	-.1000000E+02
.7980000E+01	2.1529	482.7990	-.7.1254	.400000	237.92919	20.0000	.1000000E+02	-.1000000E+02
.7990000E+01	1.6331	493.6955	-.9.3215	.300000	320.60000	10.0000	.1000000E+02	-.1000000E+02
.7900000E+01	1.2664	504.7341	-.12.0953	.200000	320.60000	0.0000	.1000000E+02	-.1000000E+02
.7910000E+01	1.0093	515.1100	-.15.6324	.165000	315.00000	10.0000	.1000000E+02	-.1000000E+02
.7920000E+01	.8700	524.9409	-.20.3000	.090000	315.00000	20.0000	.1000000E+02	-.1000000E+02
.7930000E+01	.7831	534.2126	-.26.4455	.007000	282.30170	30.0000	.1000000E+02	-.1000000E+02
.7940000E+01	.7337	542.9496	-.30.6916	.036000	26.07925	40.0000	.1000000E+02	-.1000000E+02
.7950000E+01	.7027	551.2200	-.35.0551	.050000	51.00000	50.0000	.1000000E+02	-.1000000E+02
.7960000E+01	.6809	559.1200	-.40.0000	.070000	55.00000	60.0000	.1000000E+02	-.1000000E+02
.7970000E+01	.6622	566.7000	-.45.0000	.000000	50.00000	70.0000	.1000000E+02	-.1000000E+02
.7980000E+01	.6435	574.0300	-.50.0000	.000000	49.00000	80.0000	.1000000E+02	-.1000000E+02
.7990000E+01	.6230	581.1507	-.55.0000	.000000	44.00000	90.0000	.1000000E+02	-.1000000E+02
.7900000E+01	.6030	588.1176	-.60.0000	.070000	39.00000	100.0000	.1000000E+02	-.1000000E+02
.7910000E+01	.5835	594.9376	-.65.0000	.000000	34.00000	110.0000	.1000000E+02	-.1000000E+02
.7920000E+01	.5649	601.6374	-.70.0000	.050000	29.00000	120.0000	.1000000E+02	-.1000000E+02
.7930000E+01	.5460	608.2297	-.75.0000	.030000	24.00000	130.0000	.1000000E+02	-.1000000E+02
.7940000E+01	.5354	614.7224	-.80.0000	.022000	21.70000	140.0000	.1000000E+02	-.1000000E+02
.7950000E+01	.5200	621.1200	-.85.0000	.000000	19.00000	150.0000	.1000000E+02	-.1000000E+02
.7960000E+01	.5117	627.0276	-.90.0000	.012000	16.00000	160.0000	.1000000E+02	-.1000000E+02
.7970000E+01	.5100	633.6463	-.95.0000	.020000	14.00000	170.0000	.1000000E+02	-.1000000E+02
.7980000E+01	.5137	639.7799	-.100.0000	.000000	12.00000	180.0000	.1000000E+02	-.1000000E+02
.7990000E+01	.5141	645.6328	-.105.0000	.000000	10.00000	190.0000	.1000000E+02	-.1000000E+02
.7900000E+01	.5144	651.0090	-.110.0000	.000000	9.000000	200.0000	.1000000E+02	-.1000000E+02
.7910000E+01	.5160	657.7176	-.115.0000	.000000	8.000000	210.0000	.1000000E+02	-.1000000E+02
.7920000E+01	.5170	663.5614	-.120.0000	.000000	7.000000	220.0000	.1000000E+02	-.1000000E+02
.7930000E+01	.5170	669.3505	-.125.0000	.000000	6.000000	230.0000	.1000000E+02	-.1000000E+02

79940000E+01	5165	675,0224	-20,7757	091404	135,00677	1,2113	10491517E+02	10554400E+01
79940000E+01	5157	460,7949	-20,7699	091404	136,04590	1,2614	10772895E+02	10602400E+01
79960000E+01	5096	465,4657	-20,9769	091905	128,00000	1,2967	10774422E+02	10720200E+01
79970000E+01	5042	692,1110	-21,4007	095029	120,00011	1,1059	10785000E+02	10801300E+01
79980000E+01	4979	697,7193	-22,0768	078733	115,00090	1,1709	10811300E+02	10944200E+01
79990000E+01	4912	705,3537	-23,0119	070044	110,96235	1,1529	10841207E+02	11071170E+01
80000000E+01	4844	708,9590	-24,2977	060970	106,00000	1,1299	10861000E+02	11195100E+01
80010000E+01	4781	714,9565	-26,0245	049976	104,00705	1,1057	10880600E+02	11306270E+01
80020000E+01	4724	720,1291	-27,4128	037943	104,00077	1,0769	10900100E+02	11411300E+01
80030000E+01	4665	725,7669	-31,9254	025536	100,71047	1,0520	10920200E+02	11519500E+01
80040000E+01	4604	731,3514	-37,7152	013012	112,90560	1,0264	10940100E+02	11630000E+01
80050000E+01	4542	736,9257	-41,9046	007907	109,32744	1,0160	10961000E+02	11743000E+01
80060000E+01	4478	742,5114	-34,4007	010103	223,99520	1,0370	10981226E+02	11858000E+01
80070000E+01	4419	748,0955	-31,2418	030780	227,60773	1,0630	10994790E+02	11974100E+01
80080000E+01	4362	753,6781	-27,3372	042967	227,37795	1,0490	11010691E+02	12091700E+01
80090000E+01	4297	759,2900	-25,2963	054533	224,20304	1,1145	11026191E+02	12211000E+01
80100000E+01	4235	764,8380	-23,6092	064997	224,19008	1,1510	11042967E+02	12332000E+01
80110000E+01	4172	770,4147	-22,7119	073106	219,72964	1,1519	11061124E+02	12454000E+01
80120000E+01	4108	776,0046	-21,9203	080403	211,02050	1,1783	11080400E+02	12577000E+01
80130000E+01	4043	781,6014	-21,3050	087253	206,15765	1,1684	11100700E+02	12701000E+01
80140000E+01	3978	787,2170	-21,0019	093829	201,18917	1,1917	11121000E+02	12826000E+01
80150000E+01	3911	792,8555	-20,9733	099168	196,14050	1,1950	11141000E+02	12952000E+01
80160000E+01	3842	798,5243	-21,1361	004770	191,06102	1,1924	11161000E+02	13079000E+01
80170000E+01	3771	804,2307	-21,3035	004106	185,94041	1,1657	11181000E+02	13207000E+01
80180000E+01	3700	809,9021	-22,1419	078106	180,00035	1,1695	11201000E+02	13336000E+01
80190000E+01	3628	815,7642	-23,1051	067959	175,76442	1,1564	11221000E+02	13466000E+01
80200000E+01	3559	821,6493	-24,0666	059050	170,62090	1,1409	11241000E+02	13597000E+01
80210000E+01	3487	827,5779	-24,0797	047826	166,10000	1,0996	11261000E+02	13729000E+01
80220000E+01	3414	833,5465	-24,0933	035352	162,39108	1,0694	11281000E+02	13862000E+01
80230000E+01	3340	839,5698	-34,7316	010041	161,00000	1,0574	11301000E+02	13996000E+01
80240000E+01	3266	845,6084	-44,1466	008919	207,66090	1,0079	11321000E+02	14131000E+01
80250000E+01	3191	852,0312	-34,1021	015550	306,15009	1,0361	11341000E+02	14267000E+01
80260000E+01	3115	858,3847	-29,6071	032110	307,22462	1,0668	11361000E+02	14404000E+01
80270000E+01	3039	864,7493	-24,3543	004815	303,50000	1,1011	11381000E+02	14542000E+01
80280000E+01	2962	871,2354	-24,0410	062704	299,05000	1,1539	11401000E+02	14681000E+01
80290000E+01	2885	877,8244	-22,0778	075111	293,70015	1,1647	11421000E+02	14821000E+01
80300000E+01	2808	884,5310	-21,0556	000000	280,00000	1,1494	11441000E+02	14962000E+01
80310000E+01	2730	891,3470	-20,9171	007906	263,05717	1,1974	11461000E+02	15104000E+01
80320000E+01	2653	898,3691	-20,8736	090034	276,75782	1,1906	11481000E+02	15247000E+01
80330000E+01	2575	905,5660	-21,0144	004931	274,96005	1,1656	11501000E+02	15391000E+01
80340000E+01	2497	913,0103	-22,7743	072600	270,02660	1,1567	11521000E+02	15536000E+01
80350000E+01	2419	920,7592	-25,3029	053007	276,57166	1,1137	11541000E+02	15682000E+01
80360000E+01	2340	928,6708	-20,9455	035000	300,00000	1,0780	11561000E+02	15829000E+01
80370000E+01	2262	937,4376	-25,0024	050970	334000	1,1074	11581000E+02	15977000E+01
80380000E+01	2183	946,4951	-19,0922	101249	14,99736	1,2253	11601000E+02	16126000E+01
80390000E+01	2104	956,0253	-15,0129	159572	14,34000	1,4004	11621000E+02	16276000E+01
80400000E+01	2025	966,1028	-11,9997	251199	0,73379	1,6109	11641000E+02	16427000E+01
80410000E+01	1946	976,6975	-9,3106	302351	0,00318	2,0411	11661000E+02	16579000E+01
80420000E+01	1867	987,4437	-7,1716	437943	351,94400	2,3504	11681000E+02	16732000E+01
80430000E+01	1788	998,1666	-5,4024	531941	342,50470	3,4781	11701000E+02	16886000E+01
80440000E+01	1709	1008,0069	-4,1696	610750	533,05084	4,4460	11721000E+02	17041000E+01
80450000E+01	1630	1018,4599	-3,1677	694410	523,95111	5,3447	11741000E+02	17197000E+01
80460000E+01	1551	1027,6175	-2,4150	757271	515,06056	7,2397	11761000E+02	17354000E+01
80470000E+01	1472	1035,9001	-1,0553	807671	507,55005	1,3969	11781000E+02	17512000E+01
80480000E+01	1393	1043,5423	-1,0411	891117	500,09326	12,0021	11801000E+02	17671000E+01
80490000E+01	1314	1050,3476	-1,1043	967752	490,05144	12,3067	11821000E+02	17831000E+01
80500000E+01	1235	1056,6651	-0,9060	990951	480,10492	19,1919	11841000E+02	17992000E+01
80510000E+01	1156	1061,9726	-0,7346	914904	202,71740	23,0623	11861000E+02	18154000E+01
80520000E+01	1077	1066,9459	-0,6047	982718	270,10427	20,7012	11881000E+02	18317000E+01
80530000E+01	998	1071,4350	-0,5050	943513	278,09731	24,4664	11901000E+02	18481000E+01
80540000E+01	919	1075,9610	-0,4277	991949	268,76729	46,0223	11921000E+02	18646000E+01
80550000E+01	840	1079,3167	-0,3670	990000	268,00000	47,5960	11941000E+02	18812000E+01
80560000E+01	761	1082,7675	-0,3166	963900	268,11938	58,2850	11961000E+02	18979000E+01
80570000E+01	682	1085,9511	-0,2757	900007	268,00000	64,1087	11981000E+02	19147000E+01
80580000E+01	603	1088,9001	-0,2490	971449	257,27011	70,0444	12001000E+02	19316000E+01
80590000E+01	524	1091,6419	-0,2219	974770	256,05350	76,0094	12021000E+02	19486000E+01
80600000E+01	445	1094,1996	-0,2001	977281	451,21181	86,0002	12041000E+02	19657000E+01
80610000E+01	366	1096,5933	-0,1818	979203	449,92595	93,7068	12061000E+02	19829000E+01
80620000E+01	287	1098,6396	-0,1663	981400	247,78000	99,0000	12081000E+02	19992000E+01
80630000E+01	208	1100,9539	-0,1529	982605	245,73397	99,0000	12101000E+02	20156000E+01
80640000E+01	129	1102,9082	-0,1414	983801	244,05378	99,0000	12121000E+02	20321000E+01
80650000E+01	50	1104,8338	-0,1314	984999	242,05100	99,0000	12141000E+02	20487000E+01
80660000E+01	26	1106,6205	-0,1225	986194	240,34282	99,0000	12161000E+02	20654000E+01
80670000E+01	27	1108,3166	-0,1147	986876	238,72014	99,0000	12181000E+02	20822000E+01
80680000E+01	28	1109,9276	-0,1078	987666	237,17667	99,0000	12201000E+02	20991000E+01
80690000E+01	29	1111,4663	-0,1016	988470	236,76634	99,0000	12221000E+02	21161000E+01

LOCK YOUNG FILTER  
FILTER DESIGN PLOTS

STANDING WAVE RATIO AND TIME DELAY VS FREQUENCY  
SYMBOL FOR GRAPH 1 (STANDING WAVE RATIO VS FREQUENCY) S  
SYMBOL FOR GRAPH 2 (TIME DELAY VS FREQUENCY) O  
SYMBOL FOR GRAPH 3 (INSERTION LOSS VS FREQUENCY) U



A-11

LOCK YOUNG FILT-1  
FILTER DESIGN PLOTS

1 SYMBOL FOR GNAPH 1 (STANDING WAVE RATIO VS FREQUENCY) = 0  
SYMBOL FOR GNAPH 2 (INSERTION PHASE VS FREQUENCY) = 0  
SYMBOL FOR GNAPH 3 (INSERTION LOSS VS FREQUENCY) = 0

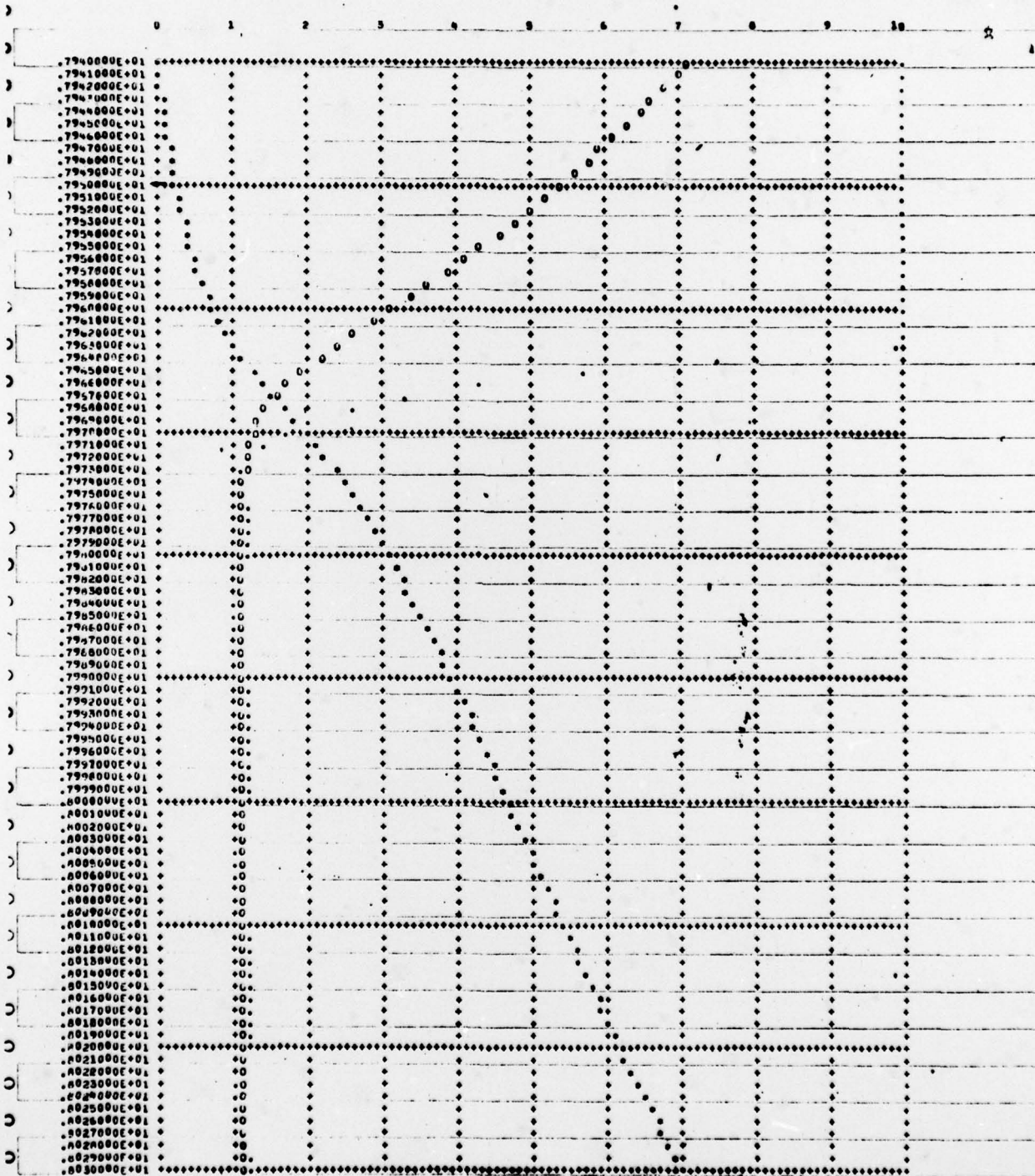
Y AXIS SCALE

PLOT	LOWER
1	.0000E+01
P	.0000E+01
A	-.0000E+01

CLATER  
 . 20064.01  
 . 78552.03  
 . 20062.02

UPPER

• 1000E+02  
• 1111E+04  
• 4500E+02





# DESIGN

## LUCK YOUNG FILTER

.0000 D<sub>0</sub> LUMS POINT

5 CAVITIES

.0000 D<sub>0</sub> NIPPLE

TIME-TO-CHEFF FILTER

ORIGINAL F1 = 7974.00000 F2 = 8656.00000 BANDWIDTH = 42.00000 F0 = 8004.00000  
 CORRECTED F1 = 7974.00000 F2 = 8656.00000 BANDWIDTH = 42.00000 F0 = 8004.00000

A = 1.37200 B = .62200000 I = .00000 C = 1.00000  
 GJ = 10000.00000 H = 1.00000000 M = .00000 ELB = .07500  
 DNEA-PH = 1.00000 DOL = .00000000 LO = .00000 RHM = 0.00000

### DESIGN CHARACTERISTICS

LAMDA-00/4 =

.007000 INCHES

1.110100 CM.

G

.0171

.9576

1.3704

1.7075

1.3704

.9576

.0171

B

7.9406

66.9378

91.0217

91.0217

66.9378

7.9406

0.0000

CAVITY LENGTH (CL)

.03304

.16697

.06000

.06697

.03304

0.00000

0.00000

### PRACTICAL DESIGN DIMENSIONS

### SUBSTANCE FOR THE SYMMETRIC NAME.

CAVITY LENGTH (CL)

.06903

.00434

.00097

GAP WIDTH (G)

.387384

.103460

.103497

SUBSTANCE (S)

7.29032

65.81000

89.20284

B1

27.28296

60.00000

70.29004

DELTA L

.00994

.00407

.00395

## FILTER DESIGN - ANALYSIS OUTPUT

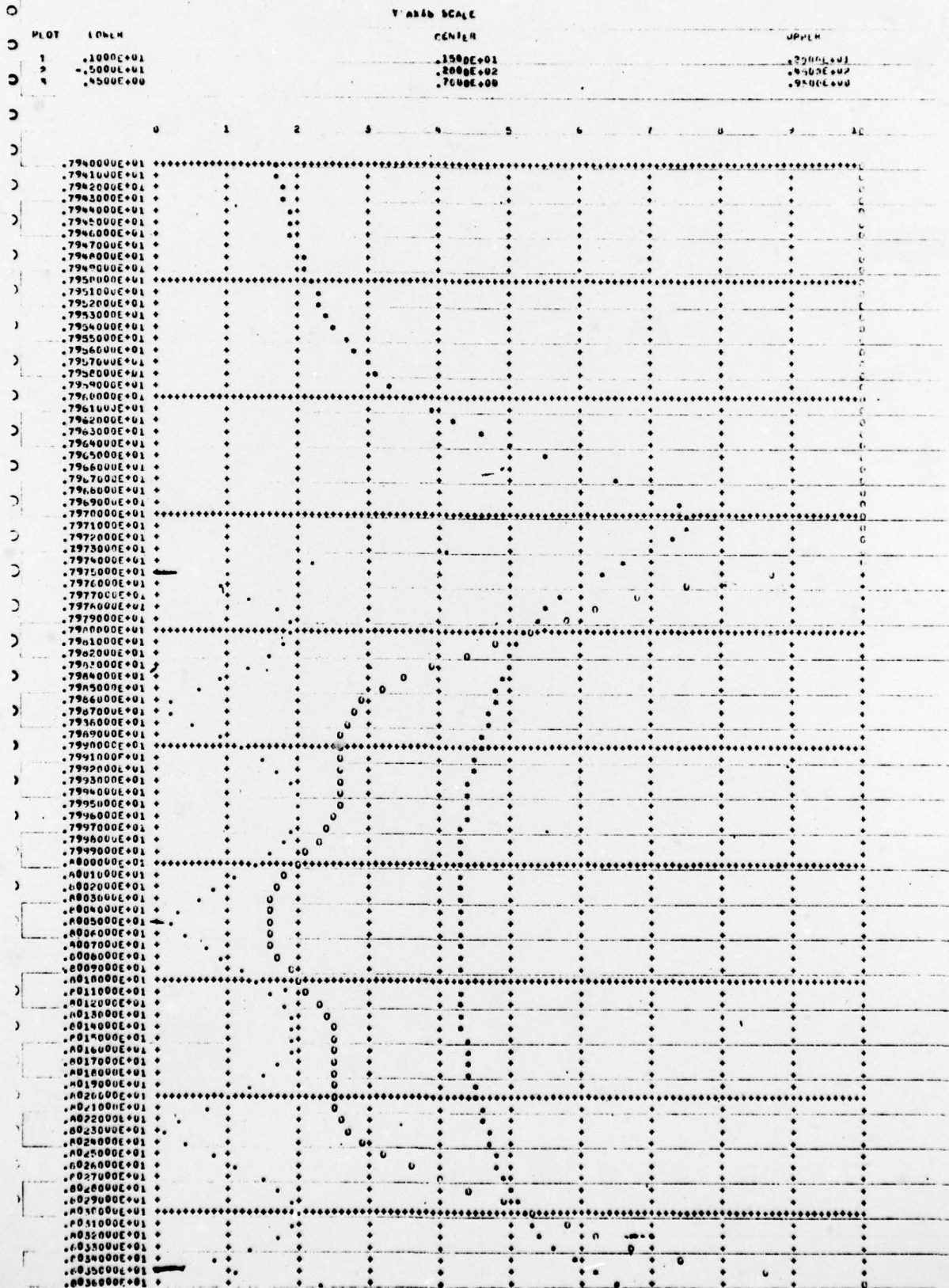
### LUCK YOUNG FILTER

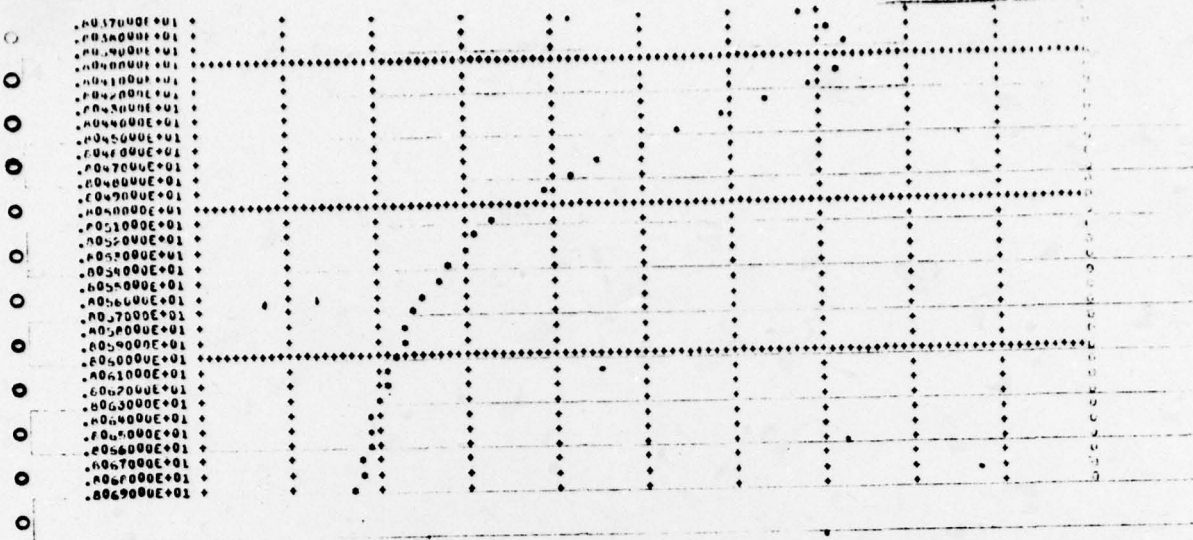
FREQUENCY	INSERTION LOSS	INSERTION PHASE	GAMMA (DB)	ABS VALUE OF GAMMA	ANGLE OF GAMMA	STANDING WAVE RATIO	GROUP DELAY (NS)	DISPERSION
.7940000E+01	33.7637	350.0705	-.0030	.999950	102.79640	99.0000	.0557009E+01	-.1451200E+02
.7941000E+01	33.0063	351.3799	-.0073	.999000	101.54825	99.0000	.0727366E+01	-.1450000E+02
.7942000E+01	32.2173	352.7406	-.0920	.989449	100.24498	99.0000	.0864296E+01	-.1447750E+02
.7943000E+01	31.4101	354.1411	-.0971	.980862	98.98126	99.0000	.0972357E+01	-.1440000E+02
.7944000E+01	30.5860	355.6023	-.1024	.970249	97.65225	99.0000	.1071700E+01	-.1430000E+02
.7945000E+01	29.7442	357.2588	-.1091	.957513	95.25434	99.0000	.1163000E+01	-.1415000E+02
.7946000E+01	28.8836	359.0162	-.1172	.942711	92.77556	99.0000	.1255283E+01	-.1395000E+02
.7947000E+01	28.0039	360.8621	-.1261	.925814	90.21531	99.0000	.1359948E+01	-.1369000E+02
.7948000E+01	27.1035	362.8044	-.1350	.906739	87.56352	99.0000	.1476984E+01	-.1335000E+02
.7949000E+01	26.1817	364.8432	-.1442	.885469	84.81140	99.0000	.1606164E+01	-.1295000E+02
.7950000E+01	25.2375	366.9769	-.1539	.862026	81.96490	99.0000	.1747355E+01	-.1240000E+02
.7951000E+01	24.2651	369.2137	-.1644	.836462	78.04442	99.0000	.1900590E+01	-.1175000E+02
.7952000E+01	23.2759	371.6520	-.1761	.808830	73.04459	99.0000	.2066964E+01	-.1095000E+02
.7953000E+01	22.2564	374.2906	-.1896	.779433	66.97807	99.0000	.2246520E+01	-.1005000E+02
.7954000E+01	21.2098	377.1291	-.2047	.748459	59.73104	77.3057	.2439370E+01	-.9000000E+01
.7955000E+01	20.1336	379.1103	-.2213	.716170	51.39960	69.1214	.2645917E+01	-.7940000E+01
.7956000E+01	19.0270	382.2215	-.2390	.682813	42.05040	61.4101	.2866247E+01	-.6900000E+01
.7957000E+01	17.8894	385.5591	-.2574	.648473	31.67421	53.6400	.3100389E+01	-.5900000E+01
.7958000E+01	16.7198	389.2698	-.2763	.613167	20.37421	46.4100	.3348364E+01	-.4950000E+01
.7959000E+01	15.5167	393.3920	-.2954	.576976	8.17060	39.6571	.3610399E+01	-.4050000E+01
.7960000E+01	14.2817	397.9770	-.3146	.540172	57.56241	33.3404	.3886639E+01	-.3200000E+01
.7961000E+01	13.0159	402.6111	-.3339	.503119	56.95720	27.0199	.4187244E+01	-.2400000E+01
.7962000E+01	11.7230	408.0519	-.3531	.465840	47.02600	20.4855	.4512374E+01	-.1650000E+01
.7963000E+01	10.4080	414.1291	-.3716	.428449	36.09110	17.3883	.4862324E+01	-.9500000E+00
.7964000E+01	9.0674	420.9404	-.3894	.390970	24.64149	14.1301	.5236244E+01	.1950000E+00
.7965000E+01	7.7732	428.5043	-.4066	.353428	12.50807	10.9176	.5634170E+01	.4290000E+00
.7966000E+01	6.5297	437.1422	-.4231	.315874	8.51040	8.5104	.6056144E+01	.7010000E+00
.7967000E+01	5.2794	446.6505	-.4390	.278473	11.60240	6.4604	.6502144E+01	.9510000E+00
.7968000E+01	4.0174	457.0429	-.4543	.241240	8.11409	4.7624	.6972314E+01	.1190000E+01
.7969000E+01	3.2166	468.2102	-.4690	.204268	5.04605	3.5624	.7466394E+01	.1470000E+01
.7970000E+01	2.4369	479.6271	-.4830	.167500	3.19775	2.7087	.7984740E+01	.1790000E+01
.7971000E+01	1.6449	491.5606	-.4963	.130940	1.82100	2.1096	.8528114E+01	.2140000E+01
.7972000E+01	1.0270	503.0751	-.5090	.927877	.828150	1.6290	.9097104E+01	.2510000E+01
.7973000E+01	1.1523	514.1000	-.5210	.679440	.310170	1.4090	.9692464E+01	.2890000E+01
.7974000E+01	.9828	524.5406	-.5324	.498044	.107054	1.2174	.1031601E+02	.3280000E+01
.7975000E+01	.8030	534.3441	-.5432	.371249	.380459	1.0683	.1070273E+02	.3680000E+01
.7976000E+01	.6240	543.5711	-.5535	.270944	.297402	1.0075	.1109399E+02	.4090000E+01
.7977000E+01	.7866	552.2903	-.5632	.191011	.1574025	1.1300	.1149974E+02	.4510000E+01
.7978000E+01	.7622	560.6123	-.5724	.137740	.081300	1.1879	.1192014E+02	.4950000E+01
.7979000E+01	.7367	568.5936	-.5810	.106247	.043446	1.1664	.1235514E+02	.5400000E+01
.7980000E+01	.7150	576.3094	-.5890	.080773	.027344	1.1528	.1280484E+02	.5860000E+01
.7981000E+01	.6922	583.0127	-.5964	.061344	.016230	1.1464	.1326824E+02	.6340000E+01
.7982000E+01	.6687	589.1430	-.6033	.047714	.008002	1.1452	.1374534E+02	.6840000E+01
.7983000E+01	.6445	594.8273	-.6097	.038704	.004000	1.1494	.1423624E+02	.7360000E+01
.7984000E+01	.6187	600.3047	-.6157	.033704	.002000	1.1590	.1474104E+02	.7900000E+01

79850000E+01	6102	612,3261	-81,2169	8879000	26,9729	1,4366	1910730E+02	1600700E+01
79860000E+01	5975	617,1578	-88,0891	8899000	28,6867	1,4361	1910730E+02	1600700E+01
79870000E+01	5806	625,0661	-90,1762	8909000	29,7128	1,4356	1910730E+02	1600700E+01
79880000E+01	5635	632,5178	-91,5678	8929000	30,7522	1,4354	1910730E+02	1600700E+01
79890000E+01	5468	639,8697	-92,8818	8949000	31,8022	1,4351	1910730E+02	1600700E+01
79900000E+01	5303	645,9518	-94,9808	8969000	32,8622	1,4349	1910730E+02	1600700E+01
79910000E+01	5140	651,8667	-96,3167	8989000	33,9322	1,4346	1910730E+02	1600700E+01
79920000E+01	4977	658,1447	-97,1749	8999000	34,0022	1,4344	1910730E+02	1600700E+01
79930000E+01	4814	664,8611	-98,0128	9009000	35,0722	1,4341	1910730E+02	1600700E+01
79940000E+01	4651	671,5768	-98,8128	9019000	36,1422	1,4339	1910730E+02	1600700E+01
79950000E+01	4488	678,6868	-99,8092	9029000	37,2122	1,4336	1910730E+02	1600700E+01
79960000E+01	4325	685,6868	-100,8092	9039000	38,2822	1,4334	1910730E+02	1600700E+01
79970000E+01	4162	692,6868	-101,8092	9049000	39,3522	1,4331	1910730E+02	1600700E+01
79980000E+01	3999	699,6868	-102,8092	9059000	40,4222	1,4329	1910730E+02	1600700E+01
79990000E+01	3836	706,6868	-103,8092	9069000	41,4922	1,4326	1910730E+02	1600700E+01
80000000E+01	3673	713,6868	-104,8092	9079000	42,5622	1,4324	1910730E+02	1600700E+01
80010000E+01	3510	720,6868	-105,8092	9089000	43,6322	1,4321	1910730E+02	1600700E+01
80020000E+01	3347	727,6868	-106,8092	9099000	44,7022	1,4319	1910730E+02	1600700E+01
80030000E+01	3184	734,6868	-107,8092	9109000	45,7722	1,4316	1910730E+02	1600700E+01
80040000E+01	3021	741,6868	-108,8092	9119000	46,8422	1,4314	1910730E+02	1600700E+01
80050000E+01	2858	748,6868	-109,8092	9129000	47,9122	1,4311	1910730E+02	1600700E+01
80060000E+01	2695	755,6868	-110,8092	9139000	48,9822	1,4309	1910730E+02	1600700E+01
80070000E+01	2532	762,6868	-111,8092	9149000	50,0522	1,4306	1910730E+02	1600700E+01
80080000E+01	2369	769,6868	-112,8092	9159000	51,1222	1,4304	1910730E+02	1600700E+01
80090000E+01	2206	776,6868	-113,8092	9169000	52,1922	1,4301	1910730E+02	1600700E+01
80100000E+01	2043	783,6868	-114,8092	9179000	53,2622	1,4299	1910730E+02	1600700E+01
80110000E+01	1880	790,6868	-115,8092	9189000	54,3322	1,4296	1910730E+02	1600700E+01
80120000E+01	1717	797,6868	-116,8092	9199000	55,4022	1,4294	1910730E+02	1600700E+01
80130000E+01	1554	804,6868	-117,8092	9209000	56,4722	1,4291	1910730E+02	1600700E+01
80140000E+01	1391	811,6868	-118,8092	9219000	57,5422	1,4289	1910730E+02	1600700E+01
80150000E+01	1228	818,6868	-119,8092	9229000	58,6122	1,4286	1910730E+02	1600700E+01
80160000E+01	1065	825,6868	-120,8092	9239000	59,6822	1,4284	1910730E+02	1600700E+01
80170000E+01	902	832,6868	-121,8092	9249000	60,7522	1,4281	1910730E+02	1600700E+01
80180000E+01	739	839,6868	-122,8092	9259000	61,8222	1,4279	1910730E+02	1600700E+01
80190000E+01	576	846,6868	-123,8092	9269000	62,8922	1,4276	1910730E+02	1600700E+01
80200000E+01	413	853,6868	-124,8092	9279000	63,9622	1,4274	1910730E+02	1600700E+01
80210000E+01	250	860,6868	-125,8092	9289000	65,0322	1,4271	1910730E+02	1600700E+01
80220000E+01	87	867,6868	-126,8092	9299000	66,1022	1,4269	1910730E+02	1600700E+01
80230000E+01	-96	874,6868	-127,8092	9309000	67,1722	1,4266	1910730E+02	1600700E+01
80240000E+01	-259	881,6868	-128,8092	9319000	68,2422	1,4264	1910730E+02	1600700E+01
80250000E+01	-422	888,6868	-129,8092	9329000	69,3122	1,4261	1910730E+02	1600700E+01
80260000E+01	-585	895,6868	-130,8092	9339000	70,3822	1,4259	1910730E+02	1600700E+01
80270000E+01	-748	902,6868	-131,8092	9349000	71,4522	1,4256	1910730E+02	1600700E+01
80280000E+01	-911	909,6868	-132,8092	9359000	72,5222	1,4254	1910730E+02	1600700E+01
80290000E+01	-1074	916,6868	-133,8092	9369000	73,5922	1,4251	1910730E+02	1600700E+01
80300000E+01	-1237	923,6868	-134,8092	9379000	74,6622	1,4249	1910730E+02	1600700E+01
80310000E+01	-1400	930,6868	-135,8092	9389000	75,7322	1,4246	1910730E+02	1600700E+01
80320000E+01	-1563	937,6868	-136,8092	9399000	76,8022	1,4244	1910730E+02	1600700E+01
80330000E+01	-1726	944,6868	-137,8092	9409000	77,8722	1,4241	1910730E+02	1600700E+01
80340000E+01	-1889	951,6868	-138,8092	9419000	78,9422	1,4239	1910730E+02	1600700E+01
80350000E+01	-2052	958,6868	-139,8092	9429000	80,0122	1,4236	1910730E+02	1600700E+01
80360000E+01	-2215	965,6868	-140,8092	9439000	81,0822	1,4234	1910730E+02	1600700E+01
80370000E+01	-2378	972,6868	-141,8092	9449000	82,1522	1,4231	1910730E+02	1600700E+01
80380000E+01	-2541	979,6868	-142,8092	9459000	83,2222	1,4229	1910730E+02	1600700E+01
80390000E+01	-2704	986,6868	-143,8092	9469000	84,2922	1,4226	1910730E+02	1600700E+01
80400000E+01	-2867	993,6868	-144,8092	9479000	85,3622	1,4224	1910730E+02	1600700E+01
80410000E+01	-3030	1000,6868	-145,8092	9489000	86,4322	1,4221	1910730E+02	1600700E+01
80420000E+01	-3193	1007,6868	-146,8092	9499000	87,5022	1,4219	1910730E+02	1600700E+01
80430000E+01	-3356	1014,6868	-147,8092	9509000	88,5722	1,4216	1910730E+02	1600700E+01
80440000E+01	-3519	1021,6868	-148,8092	9519000	89,6422	1,4214	1910730E+02	1600700E+01
80450000E+01	-3682	1028,6868	-149,8092	9529000	90,7122	1,4211	1910730E+02	1600700E+01
80460000E+01	-3845	1035,6868	-150,8092	9539000	91,7822	1,4209	1910730E+02	1600700E+01
80470000E+01	-4008	1042,6868	-151,8092	9549000	92,8522	1,4206	1910730E+02	1600700E+01
80480000E+01	-4171	1049,6868	-152,8092	9559000	93,9222	1,4204	1910730E+02	1600700E+01
80490000E+01	-4334	1056,6868	-153,8092	9569000	94,9922	1,4201	1910730E+02	1600700E+01
80500000E+01	-4497	1063,6868	-154,8092	9579000	96,0622	1,4199	1910730E+02	1600700E+01
80510000E+01	-4660	1070,6868	-155,8092	9589000	97,1322	1,4196	1910730E+02	1600700E+01
80520000E+01	-4823	1077,6868	-156,8092	9599000	98,2022	1,4194	1910730E+02	1600700E+01
80530000E+01	-4986	1084,6868	-157,8092	9609000	99,2722	1,4191	1910730E+02	1600700E+01
80540000E+01	-5149	1091,6868	-158,8092	9619000	100,3422	1,4189	1910730E+02	1600700E+01
80550000E+01	-5312	1098,6868	-159,8092	9629000	101,4122	1,4186	1910730E+02	1600700E+01
80560000E+01	-5475	1105,6868	-160,8092	9639000	102,4822	1,4184	1910730E+02	1600700E+01
80570000E+01	-5638	1112,6868	-161,8092	9649000	103,5522	1,4181	1910730E+02	1600700E+01
80580000E+01	-5801	1119,6868	-162,8092	9659000	104,6222	1,4179	1910730E+02	1600700E+01
80590000E+01	-5964	1126,6868	-163,8092	9669000	105,6922	1,4176	1910730E+02	1600700E+01
80600000E+01	-6127	1133,6868	-164,8092	9679000	106,7622	1,4174	1910730E+02	1600700E+01
80610000E+01	-6290	1140,6868	-165,8092	9689000	107,8322	1,4171	1910730E+02	1600700E+01
80620000E+01	-6453	1147,6868	-166,8092	9699000	108,9022	1,4169	1910730E+02	1600700E+01
80630000E+01	-6616	1154,6868	-167,8092	9709000	109,9722	1,4166	1910730E+02	1600700E+01
80640000E+01	-6779	1161,6868	-168,8092	9719000	111,0422	1,4164	1910730E+02	1600700E+01
80650000E+01	-6942	1168,6868	-169,8092	9729000	112,1122	1,4161	1910730E+02	1600700E+01
80660000E+01	-7105	1175,6868	-170,8092	9739000	113,1822	1,4159	1910730E+02	1600700E+01
80670000E+01	-7268	1182,6868	-171,8092	9749000	114,2522	1,4156	1910730E+02	1600700E+01
80680000E+01	-7431	1189,6868	-172,8092	9759000	115,3222	1,4154	1910730E+02	1600700E+01
80690000E+01	-7594	1196,6868	-173,8092	9769000	116,3922	1,4151	1910730E+02	1600700E+01
80700000E+01	-7757	1203,6868	-174,8092	9779000	117,4622	1,4149	1910730E+02	1600700E+01
80710000E+01	-7920	1210,6868	-175,8092	9789000	118,5322	1,4146	1910730E+02	1600700E+01
80720000E+01	-8083	1217,6868	-176,8092	9799000	119,6022	1,4144	1910730E+02	1600700E+01
80730000E+01	-8246	1224,6868	-177,8092	9809000	120,6722	1,4141	1910730E+02	1600700E+01
80740000E+01	-8409	1231,6868	-178,8092	9819000	121,7422	1,4139	1910730E+02	1600700E+01
80750000E+01	-8572	1238,6868	-179,8092	9829000	122,8122	1,4136	1910730E+02	1600700E+01
80760000E+01	-8735	1245,6868	-180,8092	9839000	123,8822	1,4134	1910730E+02	1600700E+01
80770000E+01	-8898	1252,6868	-181,8092	9849000	124,9522	1,4131	1910730E+02	1600700E+01
80780000E+01	-9061	1259,6868	-182,8092	9859000	126,0222	1,4129	1910730E+02	1600700E+01
80790000E+01	-9224	1266,6868	-183,8092	9869000	127,0922	1,4126	1910730E+02	1600700E+01
80800000E+01	-9387	1273,6868	-184,8092	9879000	128,1622	1,4124	1910730E+02	1600700E+01
80810000E+01	-9550	1280,6868	-185,8092	9889000	129,2322	1,4121	1910730E+02	1600700E+01
80820000E+01	-9713	1287,6868	-186,8092	9899000	130,3022	1,4119	1910730E+02	1600700E+01
80830000E+01	-9876	1294,6868	-187,8092	9909000	131,3722	1,4116	1910730E+02	1600700E+01
80840000E+01	-1003							

LOCKE YOUNG FILTER  
FILTER DESIGN PLOTS

STANDING WAVE RATIO AND TIME DELAY VS FREQUENCY  
SYMBOL FOR GRAPH 1 (STANDING WAVE RATIO VS FREQUENCY) = \*  
SYMBOL FOR GRAPH 2 (TIME DELAY VS FREQUENCY) = o  
SYMBOL FOR GRAPH 3 (INSERTION LOSS VS FREQUENCY) = .





SYMBOL FOR GRAPH 1 (STANDING WAVE RATIO VS FREQUENCY) = \*  
SYMBOL FOR GRAPH 2 (INSERTION PHASE VS FREQUENCY) = o  
SYMBOL FOR GRAPH 3 (INSERTION LOSS VS FREQUENCY) = o

Y AXIS SCALE		X AXIS SCALE	
POINT	LOWER	CENTER	UPPER
1	.0000E+01	.0000E+01	.1000E+02
2	.3500E+03	.7300E+03	.1100E+04
3	.5000E+01	.2000E+02	.4000E+02

